3 AFFECTED ENVIRONMENT

Section 3 describes the aspects of the LLNL environment pertinent to the issues evaluated in this SEIS. Topics included are geology, soils, water use, surface water, hydrogeology, soil and groundwater quality, and ongoing remediation activities.

3.1 GEOLOGY

The Livermore Site is located within the California Coast Ranges, an area of north-northwest trending ranges and valleys. Livermore Valley forms an east-west structural basin defined by branches of the San Andreas Fault system. The site occupies a smooth land surface that slopes gently to the northwest.

The site is underlain by late Tertiary and Quaternary rocks that lie on basement rocks of the Franciscan assemblage, which consists of severely deformed sandstone, shale, and chert. In the area of Livermore, this unit is composed primarily of sandstone. The basin is filled with 1,219 m (4,000 ft) of Pliocene to Holocene alluvial gravels, sands, and lacustrine clays. Late Quaternary alluvial deposits immediately underlie the site.

The historically active, northwest-trending Calaveras fault zone (the easternmost branch of the San Andreas fault system in the San Francisco Bay area) traverses the western margin of Livermore Valley. The Concord-Green Valley fault and parallel-trending Greenville fault zone define the eastern boundary of the valley. Two other capable faults (Las Positas and Verona), as well as several inactive faults, cut the southern part of the valley. The Livermore Site lies in an area of historically inactive faulting (1.6 km [1.0 mi] north of the Las Positas fault zone and less than 3.2 km [2.0 mi] west of the Greenville fault zone [DOE 1996b]). The Calaveras fault has had several earthquakes of Richter magnitude 5.0 or greater in the last 150 years. A seismic hazard curve has been developed for the LLNL site (Geomatrix 1991). Additional details on recent seismic activity are summarized in DOE (1996b).

3.2 SOILS

The Livermore Site is located on soils classified as the Rincon-San Ysidro association. These soils are nearly level and have a loamy or gravelly texture. They range from shallow to very deep, older fans and floodplains. The erosion hazard of these soils is slight to moderate. Several of these soils, including the Rincon, San Ysidro, and Zamora series, have moderate to high shrink-swell potential. Recently, the area around the Livermore Site has been reclassified as urban and built-up land. No prime or unique farmland soils are located at the site.

3.3 WATER USE

The Livermore area relies on groundwater and imported surface water for its municipal, commercial, residential, and agricultural uses. The water from municipal supply wells is blended with imported surface water before distribution to the public. A small amount of treated groundwater is used to supplement irrigation and cooling tower makeup at LLNL (LLNL 1998).

The total annual water use at the Livermore Site is currently 968 million L/yr (256 million gal/yr) (LLNL 1998). LLNL receives this water from two suppliers. During the summer, deliveries are taken primarily from the Alameda County Flood Control and Water Quality Conservation District Zone 7. This water is a mixture of groundwater and surface water from the South Bay Aqueduct of the State Water Project. For the remainder of the year, surface water is usually supplied from the Hetch-Hetchy Aqueduct.

3.4 SURFACE WATER

The main surface water features at the Livermore Site are the Arroyo Las Positas and Arroyo Seco (Figure 3.1). Arroyo Las Positas drains the hills directly east of the site and usually flows only after a storm, except locally at the site from the discharge of treated groundwater. This arroyo enters the Livermore Site from the east, is diverted along a storm ditch around the northern edge of the site, and exits at the northwestern corner. Arroyo Seco flows though the southwestern corner of the site. Arroyo Las Positas flows into Arroyo Seco west of the site. Both channels may be dry for part of the year. Nearly all surface water runoff at the Livermore Site is discharged into Arroyo Las Positas. Only surface water runoff along the southern boundary, minor treated groundwater discharge, and some storm drains in the southwestern corner of the site drain into Arroyo Seco.

Off-site surface waters near the Livermore Site are routinely monitored for radioactive parameters. In addition, stormwater runoff from the site is monitored for radioactive and nonradioactive parameters. About 25% of the stormwater within the site drains into the lined Drainage Retention Basin; the remainder drains either directly, or via a system of storm sewers and ditches, into Arroyo Seco or Arroyo Las Positas.

Approximately 400 million L (106 million gal) of wastewater from the Livermore Site is discharged to the City of Livermore sewer system annually and processed at the Livermore Water Reclamation Plant (LLNL 1998). This wastewater includes sanitary and industrial discharges from the site and from Sandia National Laboratories, Livermore. The discharges are permitted by the City of Livermore and monitored for pH, selected metals, and radioactivity.

Wastewater treated at the Livermore Water Reclamation Plant (LWRP) is discharged into the San Francisco Bay via the Livermore Amador Valley Water Management Agency

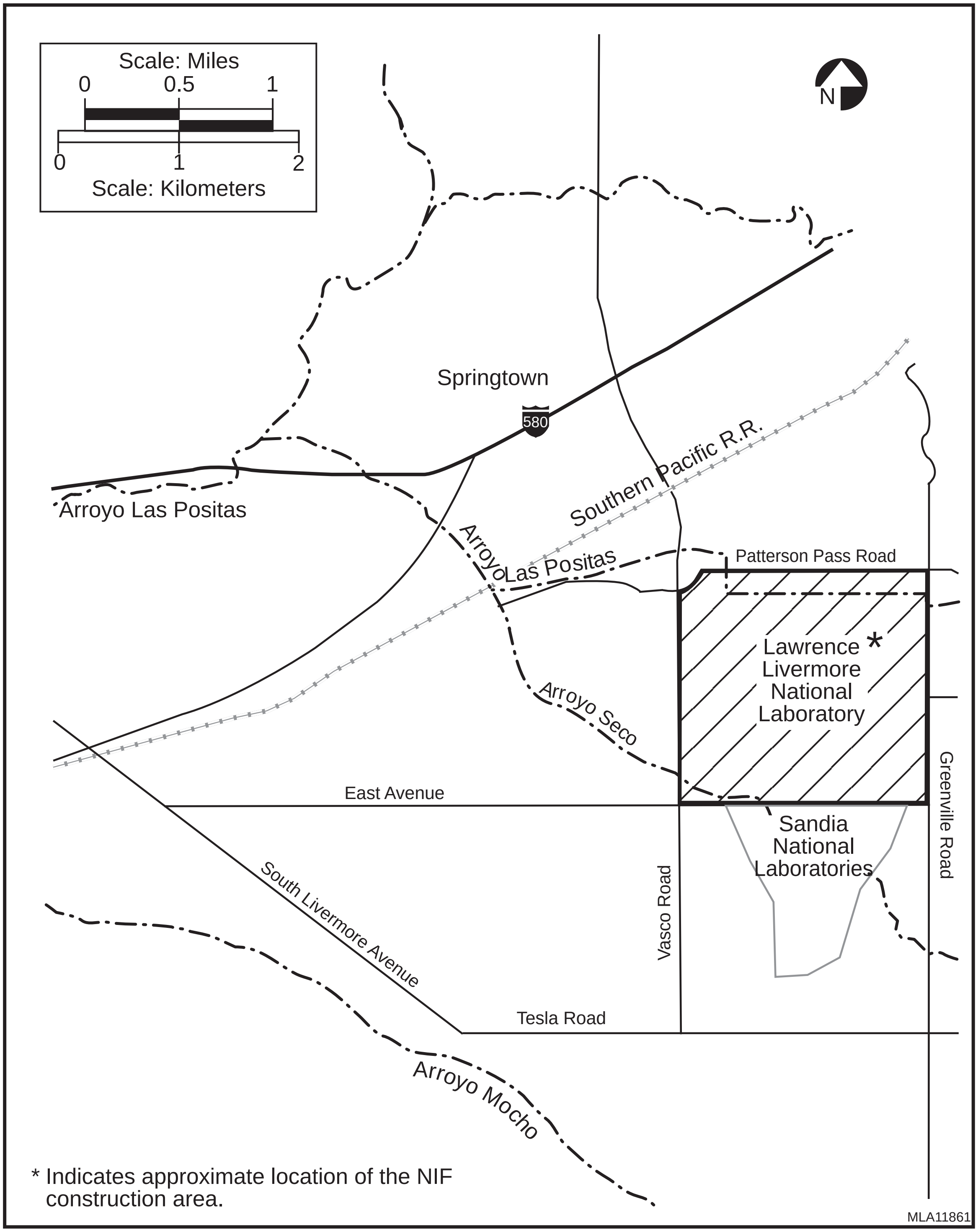

FIGURE 3.1 Surface Water Features near Lawrence Livermore National Laboratory

(LAVWMA). The City of Livermore has proposed to treat a portion of its effluent to above tertiary standards and recycle that water through groundwater injection. Toward this goal, the City of Livermore has constructed a pilot advanced wastewater treatment facility that uses reverse osmosis and microfiltration at the LWRP. The city is currently pursuing approval from the San Francisco Regional Water Quality Control Board to perform groundwater recharge with the high-quality water produced by this facility. The proposed timeline for implementation is 2002. One of the remaining isues in the review and permitting process is the potential for tritium to impact the quality of the water produced. The process wastewaters generated at NIF will not discharge to sanitary sewers or storm sewers containing tritium above background levels.

3.5 HYDROGEOLOGY

Groundwater at the Livermore Site occurs in an upper unconfined zone overlaying a series of semiconfined aquifers. The two geological units containing the most important aquifers are the surface valley-fill deposits (shallow alluvial aquifer) and the Livermore Formation, which is semiconfined. These aquifers are locally recharged by stream runoff from precipitation and controlled releases from the South Bay Aqueduct, direct rainfall infiltration, irrigation, and treated groundwater infiltration. In addition, stream channels, ditches, and gravel pits west of the City of Livermore also recharge the shallow groundwater. Recharge to the uppermost groundwater aquifer occurs primarily through infiltration of precipitation. Vogele et al. (1996) estimate that about 10% of the precipitation (33.8 mm/yr [1.33 in./yr]) recharges the shallow groundwater in the Livermore Valley.

Conceptually, groundwater near the NIF site has been characterized using six distinct hydrostratigraphic units (HSUs) (LLNL 1994a) (Figure 3.2). An HSU is defined by grouping sediments in close proximity that have similar hydraulic properties. Beneath the Livermore Site, HSU 1 is a 9- to 15-m (30- to 50-ft) thick interval of interbedded sand, silt, and gravel. HSU 1 is divided into two subunits, HSU 1A and HSU 1B. As shown in Figure 3.2, HSU 1A does not exist in the vicinity of the NIF, and HSU 1B is unsaturated there.

HSU 2 is about 14 m (45 ft) thick in the vicinity of the NIF site. HSU 2 consists of low-permeability clayey silt, silty clay, and clayey sand with interbeds of sand and sandy gravel (LLNL 1994a). In portions of the NIF site, this is the first unit that is saturated. No perched water was found in the vicinity of the NIF by groundwater investigations conducted pursuant to the Joint Stipulation and Order.

As with HSU 1, HSU 3 is divided into two subunits: HSU 3A and HSU 3B. HSU 3B consists of low-permeability silt and clay in the northeastern portion of the Livermore Site. In the vicinity of the NIF site, HSU 3A is composed of silty clay, clayey silt, and sand. In this area, the coarser-grained interbeds are thin, discontinuous, and separated by finer-grained sediments.

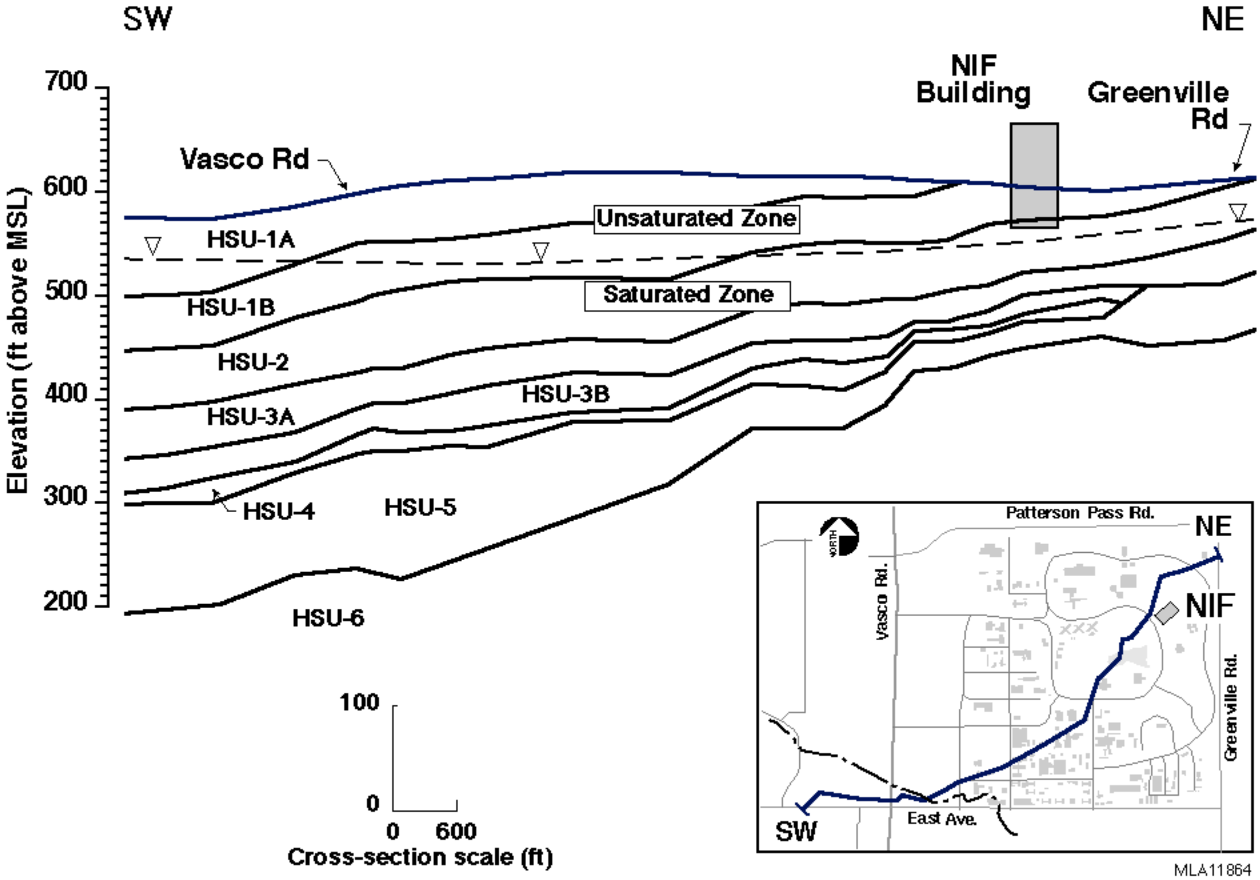

FIGURE 3.2 Generalized Cross Section Showing Hydrostratigraphic Units beneath the Livermore Site

In the area of the NIF site, HSU 4 is made up of lower permeability silt and clay, or consists of a laterally continuous, high-permeability, sand and gravel unit. It ranges in thickness from about 0.6 to 7.6 m (2 to 25 ft) (LLNL 1994a) and thins to the east.

HSU 5 is the uppermost part of the Lower Member of the Livermore Formation (LLNL 1994a). This unit is about 7-18 m (23-60 ft) thick in the vicinity of the NIF site. The unit consists of sand and gravel with interbedded silt and clay.

The upper portion of HSU 6 consists of silty clay to clayey silt, with minor interbeds of clayey sand and gravel. HSU 6 also lies within the Lower Member of the Livermore Formation.

The average groundwater flow velocity beneath the Livermore Site is about 1 m/yr (3.3 ft/yr) (Vogele et al. 1996), but varies across the site and within separate HSUs. Analysis of 18 soil samples from the vicinity of the NIF (Stephens and Associates 1996) indicates that the saturated hydraulic conductivity of the soil is variable, ranging from 5.7×10^{-8} cm/s (1.6×10^{-4} ft/d) in clayey silt to 1.8×10^{-2} cm/s (51 ft/d) in gravelly sand. The average saturated hydraulic conductivity is approximately 8.3×10^{-3} cm/s (23.4 ft/d) assuming a log normal distribution of conductivities. Hydraulic conductivity is a parameter that indicates the ease with which water will flow through a porous medium; higher conductivities allow more rapid flow.

3.6 SOIL AND GROUNDWATER QUALITY

3.6.1 Contaminants

Initial releases of hazardous materials occurred at the Livermore Site in the mid- to late-1940s, when the facility was the Livermore Naval Air Station (Berg et al. 1997). Evidence exists that localized spills, leaking tanks and impoundments, and landfills contributed volatile organic compounds (VOCs) (organic compounds that readily vaporize), fuel hydrocarbons (FHCs) (e.g., benzene, toluene, ethylbenzene, and xylene [BTEX]), and tritium to the groundwater and soils in the post-Navy era. Because of this contamination, the Livermore Site was placed on the EPA's National Priorities List in 1987. Approximately 450 wells are monitored regularly at Livermore Site to assess groundwater quality. Wells in the vicinity of the study areas are shown in Figure 3.3. In general, contaminant concentrations have decreased from historic maximums because of remediation activities.

Contaminants present at the Livermore Site at concentrations above their regulatory maximum contaminant levels (MCLs) in the groundwater include VOCs. Tritium is also present locally in groundwater above its MCL in one area outside the stipulated areas. Chromium is detected above its MCL at several locations outside the stipulated areas. However, chromium contamination in groundwater is not widespread nor serious enough to include its discussion here. PCBs have been found in soils only. LLNL is actively remediating such contamination, as appropriate, under CERCLA. The following specific contaminants for which monitoring data are available are reported in this SEIS:

- VOCs: trichloroethylene (TCE), perchloroethylene (PCE), trichlorofluoromethane (Freon 11), and carbon tetrachloride;
- Radionuclides: tritium;
- PCBs: Aroclor 1254 and unspecified mixture.

The Livermore Site has an extensive subsurface monitoring program. Since 1986, an integrated sample and data management program has supported the collection, validation, interpretation, and use of the soil and groundwater data. A highly concentrated monitoring network within the 1-mi^2 Livermore Site consists of more than 1,000 boreholes and approximately 450 regularly monitored wells.

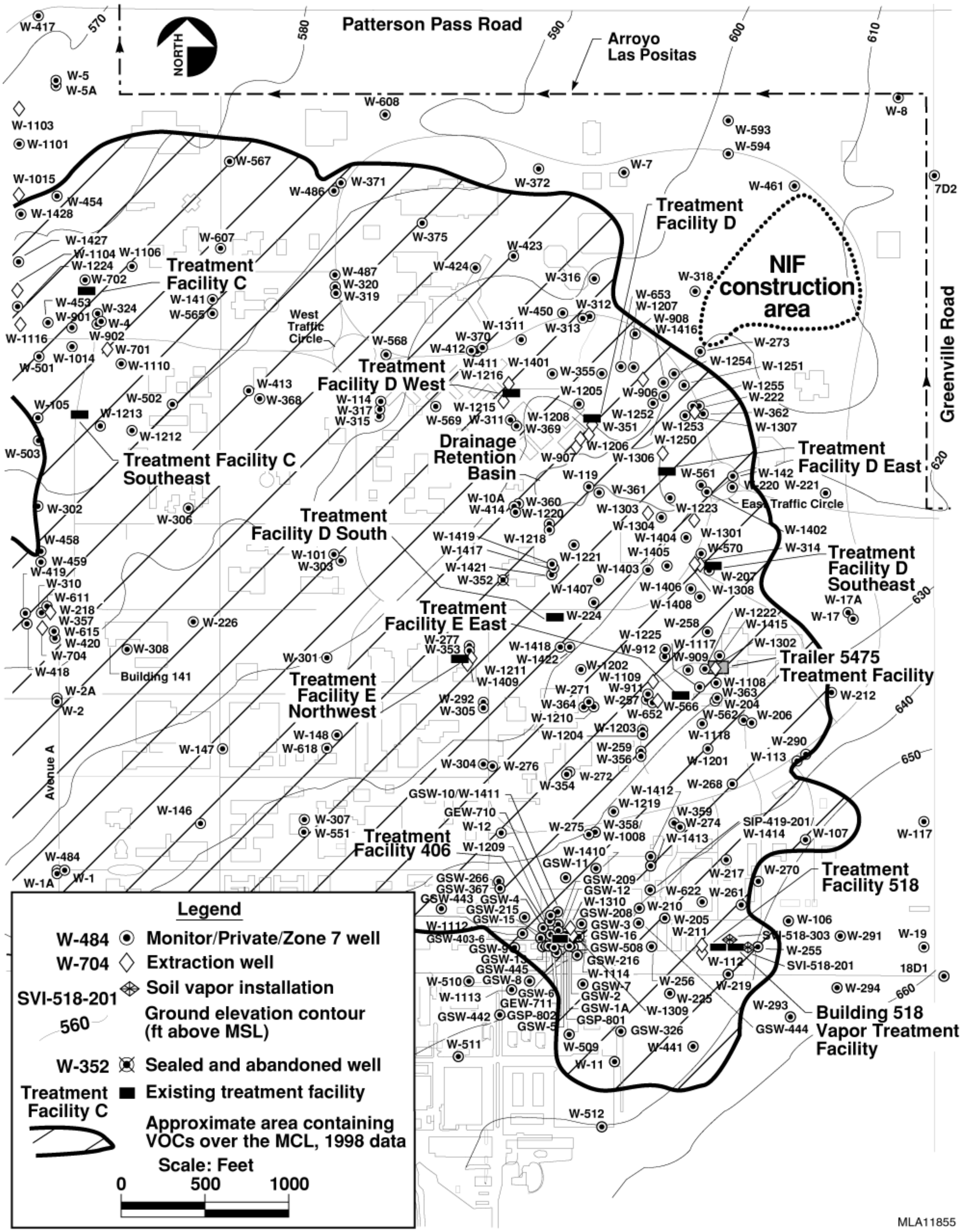

FIGURE 3.3 Eastern Portion of the Livermore Site Showing Groundwater Wells and Approximate Area Containing VOCs over the Maximum Contaminant Levels in 1998

The following subsections summarize the results of historical and current soil and groundwater monitoring for each of the areas defined in the Joint Stipulation and Order: the Helipad Area, Building 571 Area, Northern Boundary Area, Building 490 Area, East Traffic Circle Area, East Gate Drive Area, and the NIF Construction Area. Additional details on existing groundwater quality can be found in the 1998 Action Memorandum (Bainer and Berg 1998). Summaries of soil and water quality parameters are given in Tables 3.1 and 3.2 for the stipulated areas. Table 3.1 gives maximum sampled soil sediment concentrations in each area for each of six contaminants and the most recent maximum values. Values in these tables were obtained from the LLNL GEMINI database. These six contaminants were selected for inclusion in the tables because of their widespread presence at the site and the availability of concentration data. Note that the information in Sections 3.6.2 through 3.6.8 indicates that the sediment and soil values shown in Table 3.1 were not obtained at the same locations or depth. The data in Tables 3.1 and 3.2, which include both historic and current data, are consistent with the general conclusion that contaminant concentrations, particularly in groundwater, are trending downward because of remediation activities that are taking place or natural processes. A more complete evaluation and comparison of current concentrations to historic maximums and values in 1997 has been developed by Tomasko and Quinn (1999).

All results reported in the following subsections are expressed as concentrations based on measures of weight per unit volume for groundwater or weight per unit weight for soils (unsaturated sediments[1] and saturated sediments[2]). Standard convention uses different units for groundwater (µg/L or parts per billion [ppb], and mg/L or parts per million [ppm]) and soils (µg/kg or parts per billion [ppb], and µg/g or parts per million [ppm]). PCB concentrations are in units of ppm for both soils and groundwater; all other concentrations are in units of ppb, except tritium is reported as pCi/g and pCi/L. Applicable standards have also been expressed in the same units as the concentration value for ease of comparison. Concentrations of contaminants in groundwater and soils are compared to action levels consisting of applicable standards and guidelines. Soil concentrations of contaminants are compared in Table 3.1 and in Figures 3.4, 3.6, 3.8, 3.10, 3.12, 3.14, and 3.16 with the EPA Region 9 industrial Preliminary Remedial Goals (PRGs) or cleanup levels agreed to by the RPMs. Groundwater concentrations are compared to the California Maximum Contaminant Levels (MCLs) listed in drinking water standards (Table 3.2 and Figures 3.5, 3.7, 3.9, 3.11, 3.13, 3.15 and 3.17). The PRGs provided in the tables and figures are reference concentrations for comparison with the reported measured concentrations. They are relevant only to areas where cleanup actions have occurred.

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1 Unsaturated sediment: Sediment between the land surface and the water table that contains water under pressure less than an atmosphere and contains air or gases generally under atmospheric pressure. Unsaturated sediment analytical results are considered to represent residual concentrations from previous releases.

2 Saturated sediment: Sediment with void space filled with liquid. Saturated sediment analytical results are considered to represent a combination of soil and groundwater concentrations.

TABLE 3.1 Compilation of Data on Analyte Concentrations in Soil/Sediments for the Seven Study Areas (Sampling Dates in Parentheses)

Analyte	EPA Region 9 Industrial PRG[a]	Helipad Area	Bldg. 571 Area	Northern Boundary Area	Bldg. 490 Area	East Traffic Circle Area	East Gate Drive Area	NIF Construction Area
TCE (ppb)	6,100							
Historic maximum		540 (3/21/90)	200 (5/17/90)	<5 (2/20/91)	16 (4/7/89)	1,100 (5/12/89)	200 (4/6/90)	<200 (6/10/90)
Most current maximum		260 (7/21/99)	1 (10/2/90)	<5 (2/20/91)	1 (11/7/95)	286 (8/4/99)	62 (4/22/91)	<200 (6/10/90)
PCE (ppb)	19,000							
Historic maximum		<10 (4/6/90)	17 (5/17/90)	<5 (2/20/91)	1 (11/7/95)	360 (5/16/98)	9,800 (4/6/90)	200 (6/10/90)
Most current maximum		<10 (4/6/90)	5 (10/2/90)	<5 (2/20/90)	1 (11/7/95)	140 (4/21/99)	8 (6/10/90)	200 (6/10/90)
Carbon tetra-chloride (ppb)	530							
Historic maximum		23 (7/16/93)	200 (5/17/90)	<5 (2/20/91)	1 (11/7/95)	38 (8/6/96)	<200 (6/10/90)	<200 (6/10/90)
Most current maximum		7.1 (7/20/99)	200 (5/17/90)	<5 (2/20/91)	1 (11/7/95)	11 (7/11/99)	<200 (6/10/90)	<200 (6/10/90)
Trichlorofluoro-methane (Freon 11) (ppb)	2,000,000							
Historic maximum		<10 (4/6/90)	200 (5/17/90)	<5 (2/20/91)	90 (11/7/95)	1 (5/10/98)	<200 (6/10/90)	<200 (6/10/90)
Most current maximum		1 (5/14/90)	5 (5/23/90)	<5 (2/20/91)	90 (11/7/95)	1 (5/10/98)	<200 (6/10/90)	<200 (6/10/90)
Tritium[b]	45,000 pCi/g							
Historic maximum		<1 pCi/g (8/1/94)	1 pCi/g (5/30/90/)	9,000 pCi/L (2/20/91)	2,860 pCi/L (11/7/95)	62,000[c] pCi/L (2/20/91)	2,100 pCi/L (10/18/90)	<5,200 pCi/L (6/10/90)
Most current maximum		2180 pCi/L (6/18/99)	1 pCi/g (5/30/90)	9,000 pCi/L (2/20/91)	2,860 pCi/L (11/7/95)	1740 pCi/L (6/9/99)	2,100 pCi/L (10/18/90)	<5,200 pCi/L (6/10/90)
PCB (ppm)	1							
Historic maximum		0.53 (3/16/99)	4 (9/10/85)	0.19 (2/14/91)	NA[e]	133 (3/17/99)	0.53 (3/22/99)	66 (9/10/97)
Most current maximum		0.53 (3/16/99)	4 (9/10/85)	0.19 (2/14/91)	NA	16[d] (7/9/99)	0.53 (3/22/99)	<1 (10/2/97)

[a] EPA Region 9 Preliminary Remediation Goals (PRGs) for an industrial site (IRIS database).

[b] Reported as pCi/g for unsaturated soils and pCi/L for pore water in saturated soils.

[c] Measured and reported as concentration of tritium in moisture in the soil. This value is about 10,000 times greater than an equivalent solid concentration (6.2 pCi/g) because about 10% or less of the weight of soil is due to moisture and there are 1,000 g of water in a liter.

[d] Cleanup levels agreed to by the CERCLA RPMs were 1 ppm for the NIF Construction Area and 18 ppm for the ETC Area.

[e] NA = data not available.

Source: Data obtained from LLNL GEMINI database.

TABLE 3.2 Compilation of Historic Maximum, 1997, and Current Analyte Concentrations in Groundwater Samples from the Seven Study Areas

Analyte	California MCL[a]	Helipad Area	Bldg. 571 Area	Northern Boundary Area	Bldg. 490 Area	East Traffic Circle Area	East Gate Drive Area	NIF Construction Area
TCE (ppb)	5							
Historic Maximum		13,000	48	11.0	45	1,600	1.3	16
		(6/4/96)		(4/21/98)	(9/16/93)	(3/1/97)	(9/15/89)	(11/6/86)
1997		1,800	11.0	<0.5	<2.5	760	<0.5	<0.5
Current		1,900	11.0	<0.5	<2.5	550	NA[b]	NA
PCE (ppb)	5							
Historic Maximum		<100	2.4	<5	<50	1,600	<1.0	0.7
		(4/21/92)		(5/28/97)	(9/16/93)	(3.18/97)	(9/15/89)	(2/15/97)
1997		32	NA	<0.5	<2.5	1,600	<0.5	<0.5
Current		73	NA	0.54	<2.5	1,000	NA	NA
Carbon tetrachloride								
(ppb)	0.5							
Historic Maximum		230	10	<5.0	<50	120	<1.0	1.5
1997		(7/28/92)	NA	(5/28/97)	(9/16/93)	(5/27/97)	(9/15/89)	(1/31/92)
Current		51	NA	<0.5	<2.5	<2.5	<0.5	<0.5
		54		<0.5	0.9	<2.5	NA	NA
Freon 11 (ppb)	150							
Historic Maximum		<100	NA	250	1,400	<50	<1.0	1.0
		(4/24/92)	NA	(10/20/97)	(9/16/93)	<2.5	(9/15/89)	(4/5/97)
1997		<5	NA	250	480	<2.5	<0.5	<0.5
Current		<5		150	360		NA	NA
Tritium (pCi/L)	20,000							
Historic Maximum		<1,000	900	800	248	<1,000	<1,000	<1,000
		(4/24/92)		(6/20/97)	(6/28/97)	(8/14/86)	(9/15/89)	(11/6/86)
1997		NA	NA	800	248	NA	<35	NA
Current		133	NA	NA	NA	253	79	NA
PCB (ppm)	0.5							
Historic Maximum		NA	ND[c]	ND	NA	ND	ND	ND
1997		NA	NA	NA	NA	NA	NA	NA
Current		NA	ND	ND	NA	ND	ND	ND

[a] MCL = Maximum Contaminant Level.

[b] NA = No data available.

[c] ND = not detected.

Source: Data obtained from LLNL GEMINI database.

3.6.2 Helipad Area

Subsurface source investigations performed before October 1997 within the Helipad Area (Figure 1.1) included 85 soil vapor survey (SVS) points, 10 boreholes, and 15 monitor wells. Results of these surveys and those of studies conducted pursuant to the Joint Stipulation and Order are presented in Tables 3.1 (soil) and 3.2 (groundwater) and illustrated graphically in Figures 3.4 and 3.5. Major observations related to contaminants in the Helipad Area are as follows:

- VOCs at concentrations generally below 10 ppb were detected in unsaturated sediments in over half of the boreholes.

- A maximum TCE concentration of 540 ppb occurred in saturated sediments from SIB-HPA-006 in April 1990 (Table 3.1).

- A maximum groundwater TCE concentration of 13,000 ppb occurred in well W-653 in June 1996 (Table 3.2). By August 1998, this concentration had decreased to 1,900 ppb because of extraction from a pump-and-treat well located about 60 m (200 ft) west of the helipad.

- PCE and carbon tetrachloride in groundwater currently exceed MCLs.

- Tritium was recently detected in unsaturated sediment samples at a concentration of 2,180 pCi/L in pore water. In groundwater, it was recently reported at 133 pCi/L.

- Gross alpha and gross beta radioactivity were not detected, or were within natural background values, in groundwater collected from monitoring wells screened in HSU 2. Tritium concentrations in groundwater were less than 1,000 pCi/L.

- PCBs at a concentration of 0.53 ppm were detected in unsaturated sediment samples in March 1999. PCB data are not available for groundwater, but the concentration is below detectability in all areas where it has been tested, including three adjacent stipulated areas.

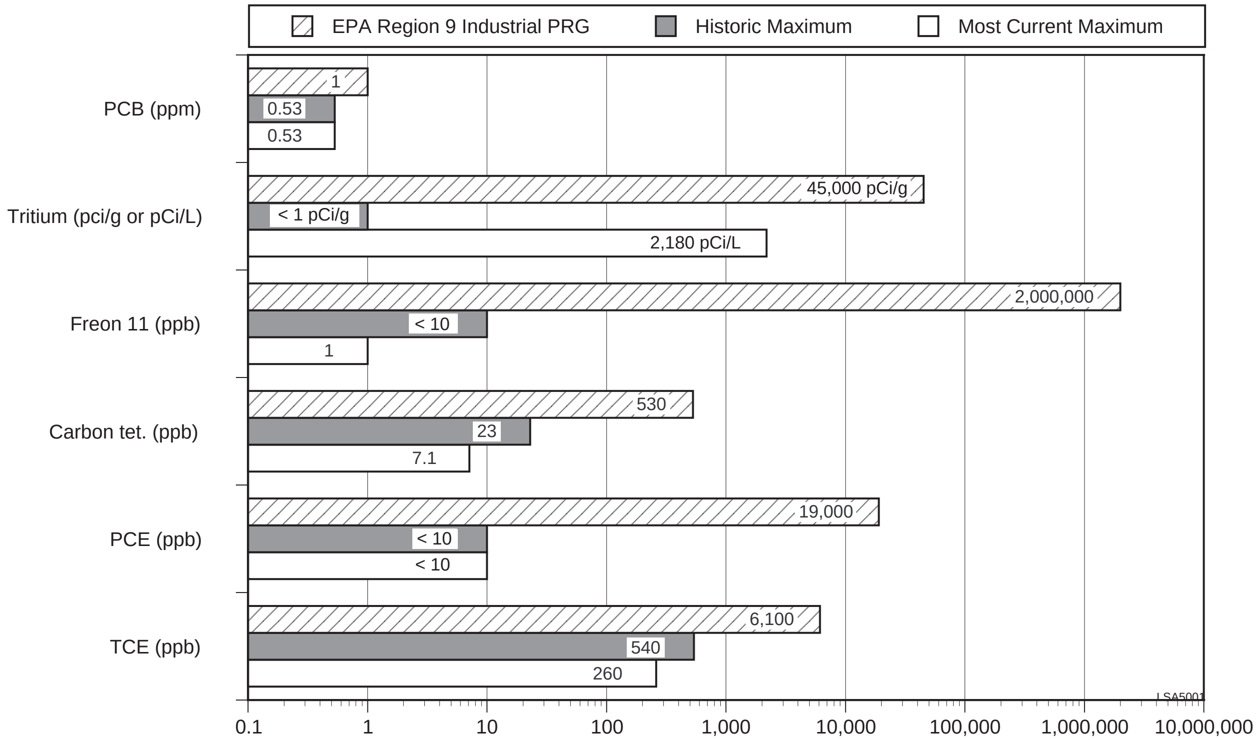

FIGURE 3.4 Soil Concentrations for the Helipad Area and EPA Region 9 Industrial Preliminary Remediation Goals (PRGs)

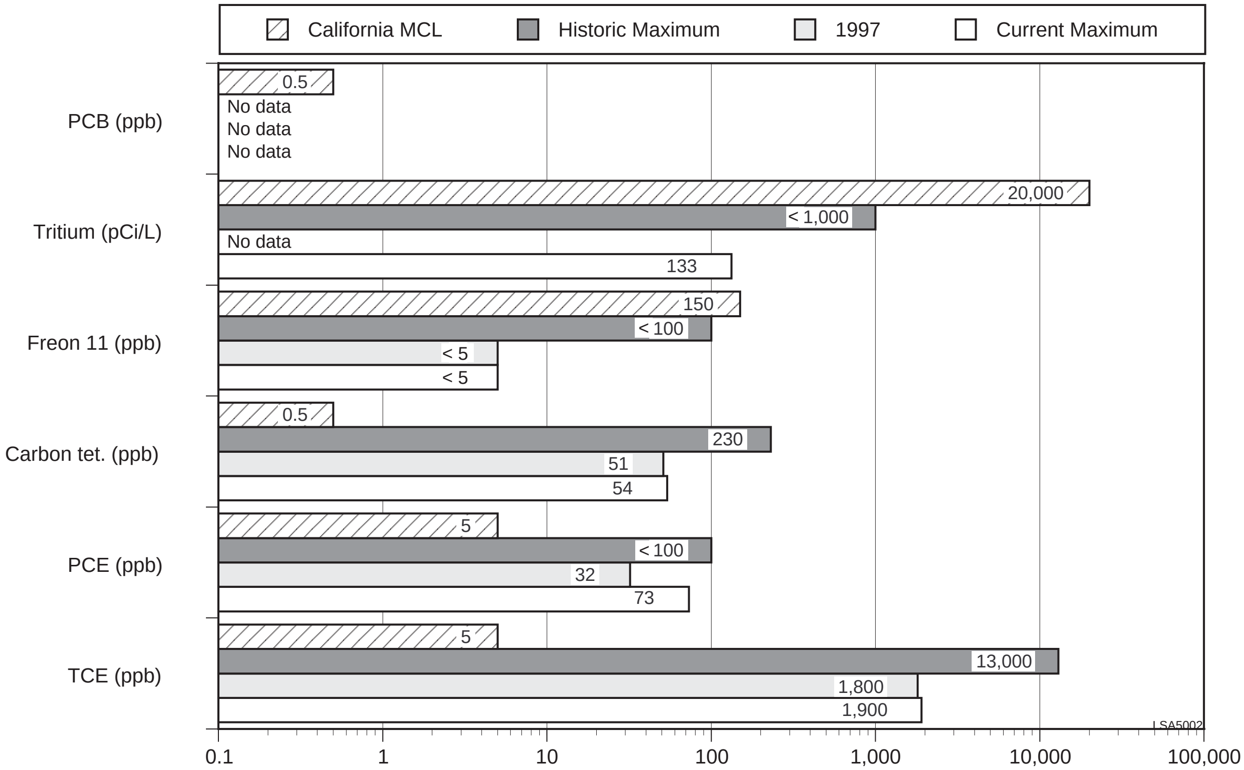

FIGURE 3.5 Groundwater Concentrations for the Helipad Area and Maximum Concentration Limits (MCLs) for Drinking Water

3.6.3 Building 571 Area

Subsurface source investigations within the Building 571 Area (Figure 1.1) before 1997 included 80 SVS points and 10 boreholes. No more recent data are available for this area. Results of the previous investigations are presented in Tables 3.1 (soil) and 3.2 (groundwater) and are illustrated graphically in Figures 3.6 and 3.7. Major observations related to contaminants in the Building 571 Area are as follows:

- VOC concentrations of 200 ppb or less were detected in shallow (less than 6 m [20 ft]), unsaturated sediments from most of the boreholes.
- PCE and TCE were detected in most soil samples, but the highest VOC concentration detected was 200 ppb for TCE, carbon tetrachloride, and Freon 11.
- Historical groundwater samples indicated the presence of VOCs, primarily TCE, with a concentration of about 48 ppb. Carbon tetrachloride (10 ppb) and PCE (2.4 ppb) have also been detected in the past.
- Tritium was not detected in any unsaturated sediment samples (<1 pCi/g); and gross alpha, gross beta, and plutonium levels in unsaturated sediment samples were not above global fallout and natural background levels.
- Tritium was detected at concentrations below 1,000 pCi/L in the groundwater.
- PCBs were detected at up to 4 ppm in September 1985 in surface soil near and downwind of the East Traffic Circle in post-cleanup sampling (McConachie et al. 1986).
- No PCBs were detected in groundwater samples.

3.6.4 Northern Boundary Area

Subsurface source investigations within the Northern Boundary Area (Figure 1.1) before October 1997 included 62 SVS points, 4 boreholes, and 1 monitor well. Results of these surveys

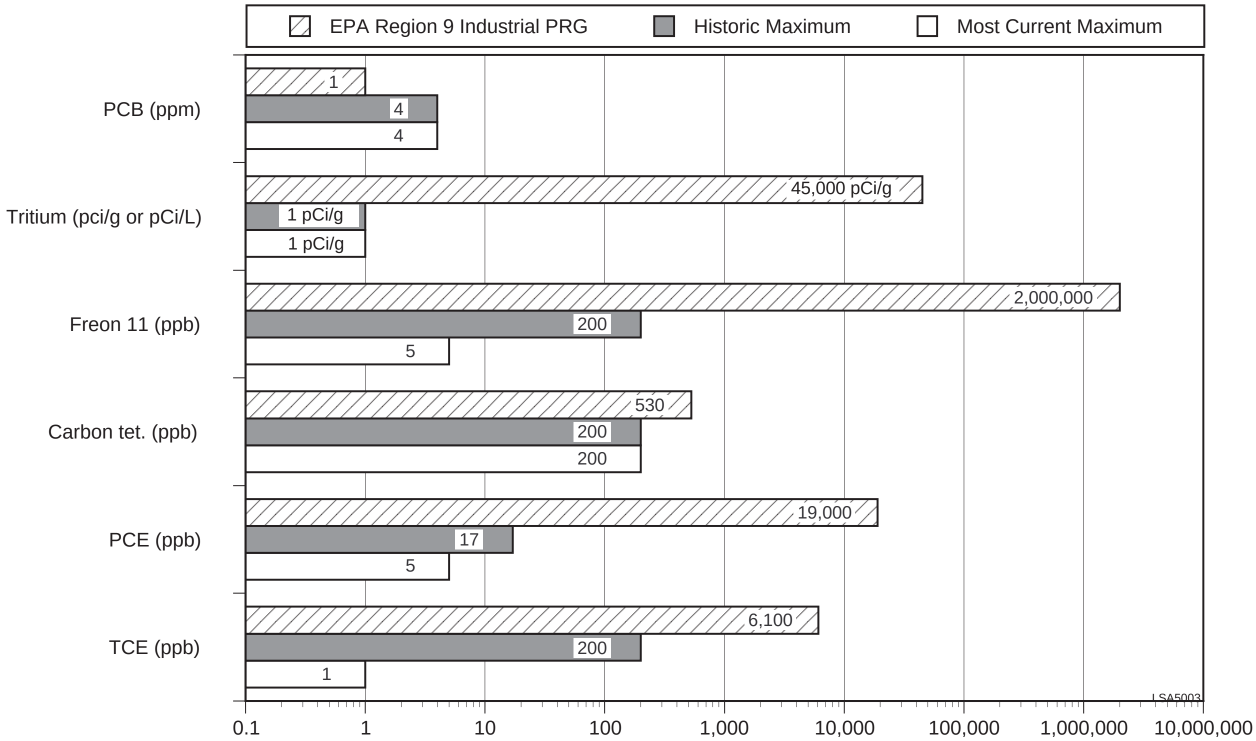

FIGURE 3.6 Soil Concentrations for the Building 571 Area and EPA Region 9 Industrial Preliminary Remediation Goals (PRGs)

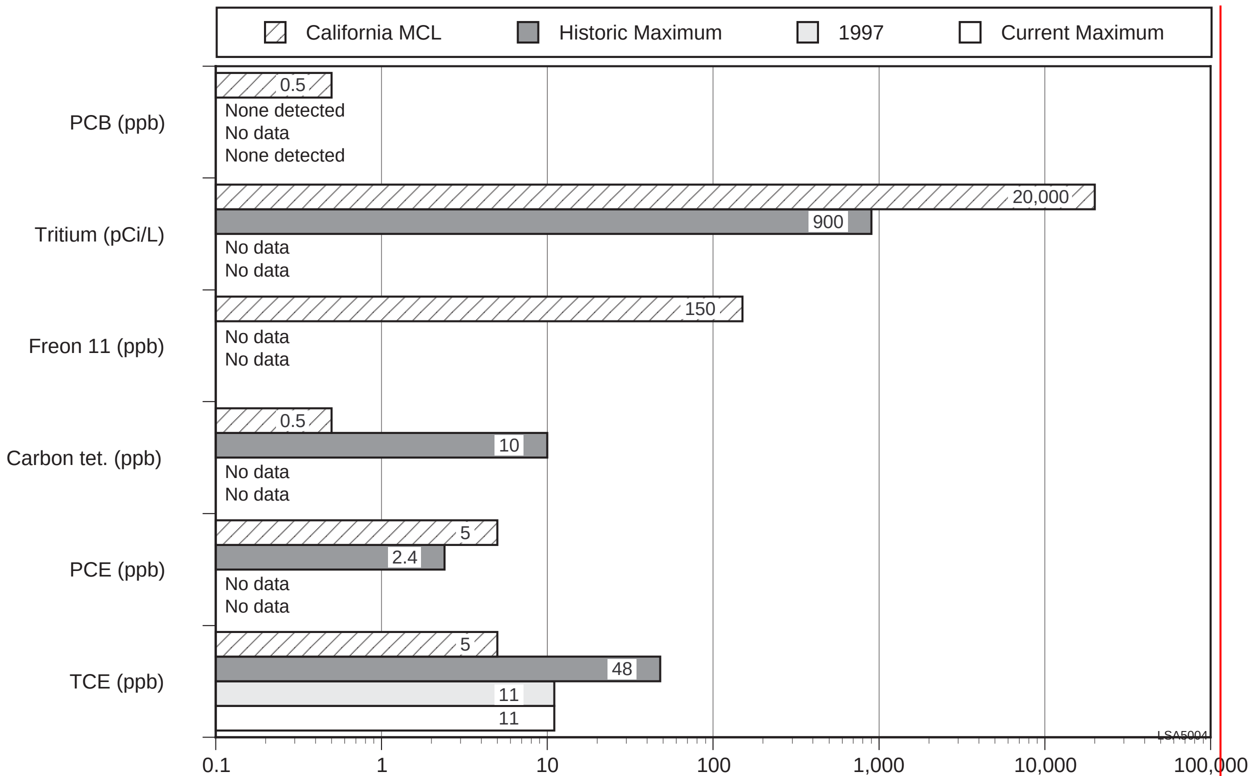

FIGURE 3.7 Groundwater Concentrations for the Building 571 Area and Maximum Concentration Limits (MCLs) for Drinking Water

and those of studies conducted pursuant to the Joint Stipulation and Order are presented in Tables 3.1 (soil) and 3.2 (groundwater) and are illustrated graphically in Figures 3.8 and 3.9. Major observations related to contaminants in the Northern Boundary Area are as follows:

- In general, no VOCs above 5 ppb were detected in sediment samples.
- Only a trace of PCE at 0.54 ppb has recently been detected in groundwater, while TCE and carbon tetrachloride are below detection.
- Historically, a maximum of 250 ppb of Freon 11 was detected in groundwater.
- Tritium was detected at a maximum concentration of 9,000 pCi/L in the water phase of one unsaturated sediment sample (borehole SIB-NBA-003). Gross alpha, gross beta, and plutonium levels in unsaturated sediment samples were not above global fallout and natural background levels.
- Tritium concentrations of 800 pCi/L were measured in groundwater samples in the vicinity of the Northern Boundary Area.
- PCBs were reported in only one unsaturated sediment sample, from a depth of 3.4 m (11 ft) at a concentration of 0.19 ppm. They are not detectable in groundwater.

3.6.5 Building 490 Area

Subsurface source investigations within the Building 490 Area (Figure 1.1) before October 1997 included 60 SVS points, 2 boreholes, and 6 monitor wells. Results of these surveys and those of studies conducted pursuant to the Joint Stipulation and Order are presented in Tables 3.1 (soil) and 3.2 (groundwater) and illustrated graphically in Figures 3.10 and 3.11. Major observations related to contaminants in the Building 490 Area are as follows:

- VOCs, predominantly Freon 11, were detected at concentrations generally less than 100 ppb in most unsaturated sediment samples collected before October 1997 from a borehole located immediately south of the building. The highest concentration of Freon 11 in saturated sediments from this borehole was 90 ppb from SIB-490-102.
- TCE and PCE were detected in saturated sediments at concentrations less than or equal to 16 ppb.

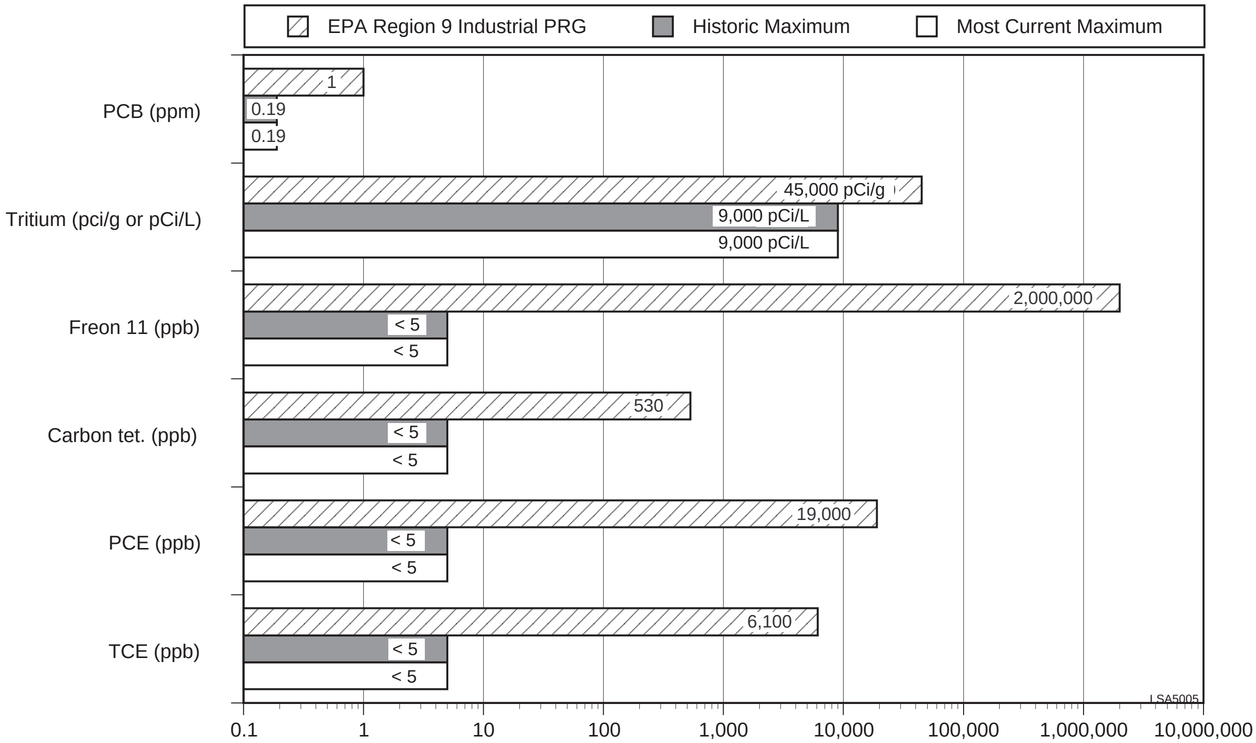

FIGURE 3.8 Soil Concentrations for the Northern Boundary Area and EPA Region 9 Industrial Preliminary Remediation Goals (PRGs)

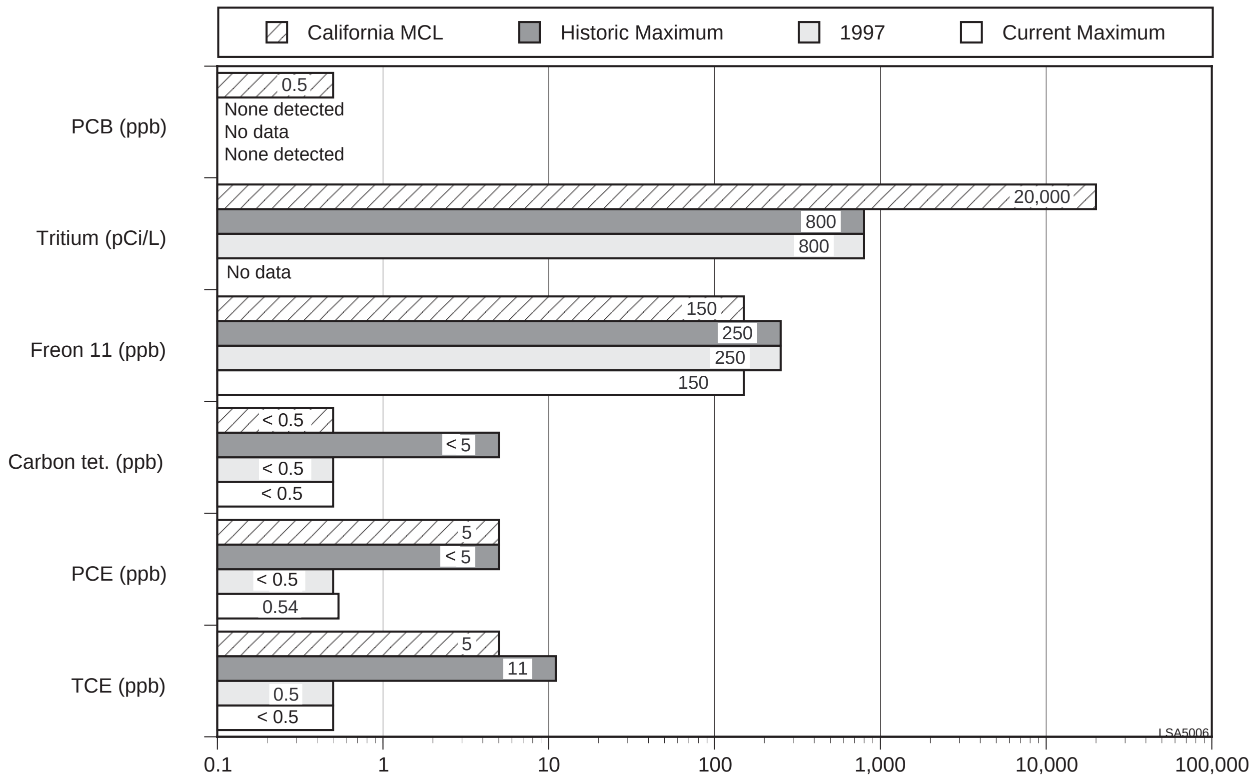

FIGURE 3.9 Groundwater Concentrations for the Northern Boundary Area and Maximum Concentration Limits (MCLs) for Drinking Water

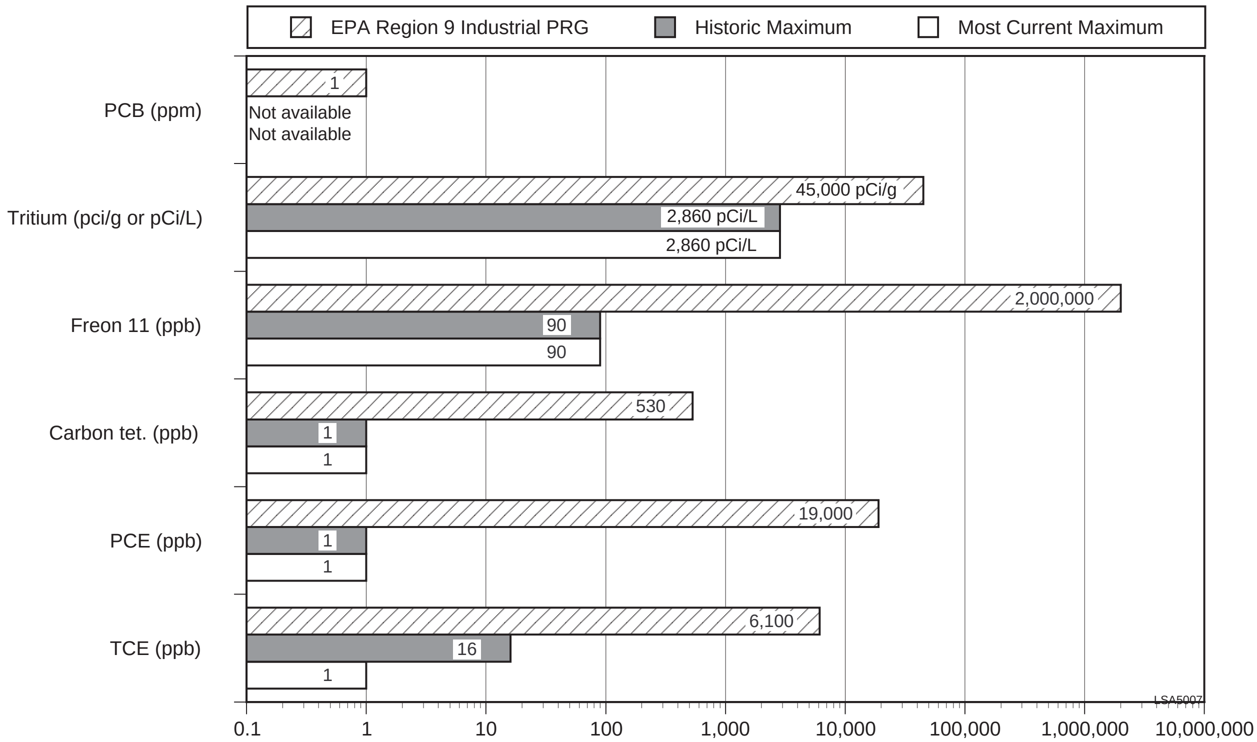

FIGURE 3.10 Soil Concentrations for the Building 490 Area and EPA Region 9 Industrial Preliminary Remediation Goals (PRGs)

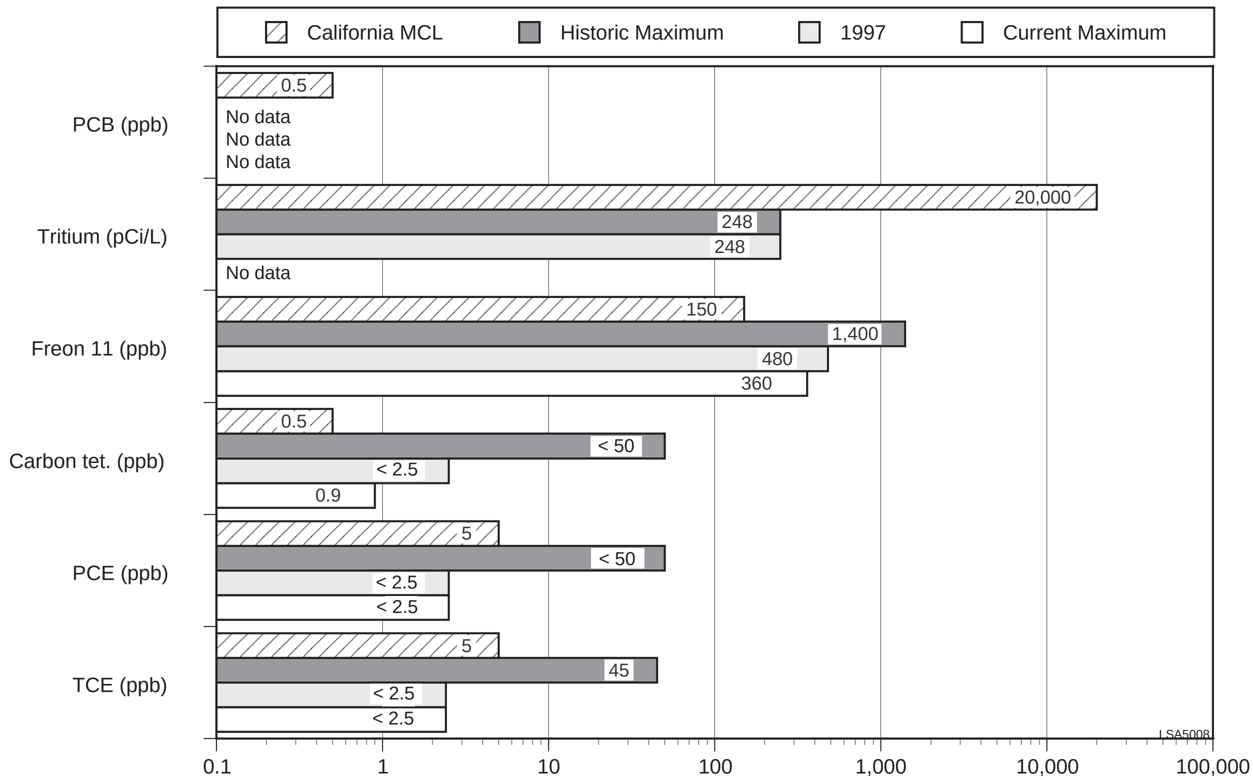

FIGURE 3.11 Groundwater Concentrations for the Building 490 Area and Maximum Concentration Limits (MCLs) for Drinking Water

- VOCs (mostly TCE) were detected in groundwater samples at concentrations up to 45 ppb; by October 1997 concentrations had decreased to less than 2.5 ppb. Carbon tetrachloride is present at trace levels (0.9 ppb).

- Freon 11 was first detected in groundwater in August 1988. The concentration increased to a high of 1,400 ppb in August 1994. Currently, the Freon 11 concentration has decreased to 360 ppb in this well.

- No metals were detected above their action levels in groundwater samples from wells screened in HSU 2.

- Tritium was sporadically detected at a concentration of about 2,860 pCi/L in sediment samples collected from one borehole (see Table 3.2).

- Tritium has not exceeded 1,000 pCi/L in groundwater samples from any of the monitor wells screened in HSU 2. Gross alpha and gross beta levels in HSU 2 groundwater downgradient of Building 490 were either below detection limits or within natural background levels.

- No soil or groundwater samples from this area have been sampled for PCBs.

3.6.6 East Traffic Circle Area

The ETC Area (Figure 1.1) contained a former landfill that was excavated in 1984. Before October 1997, source investigations were initiated after the landfill was excavated and included 119 SVS points, 30 boreholes, and 15 monitor wells. Results of these surveys, surveys conducted pursuant to the Joint Stipulation and Order, and surveys performed during PCB cleanup activities in 1998-1999 are presented in Tables 3.1 (soil) and 3.2 (groundwater) and illustrated graphically in Figures 3.12 and 3.13. Major observations related to contaminants in the ETC Area are as follows:

- VOCs (TCE and PCE) were detected in recent surveys in most of the unsaturated sediment samples at total VOC concentrations generally less than 1,000 ppb. Historic maximums are 1,100 ppb.

- Total VOC concentrations in groundwater from wells screened in HSU 2 were as high as 1,600 ppb in March 1997.

- Current VOC groundwater concentrations in HSU 2 are generally below 1,000 ppb, and in some locations have decreased to less than 100 ppb because of active pump-and-treat.

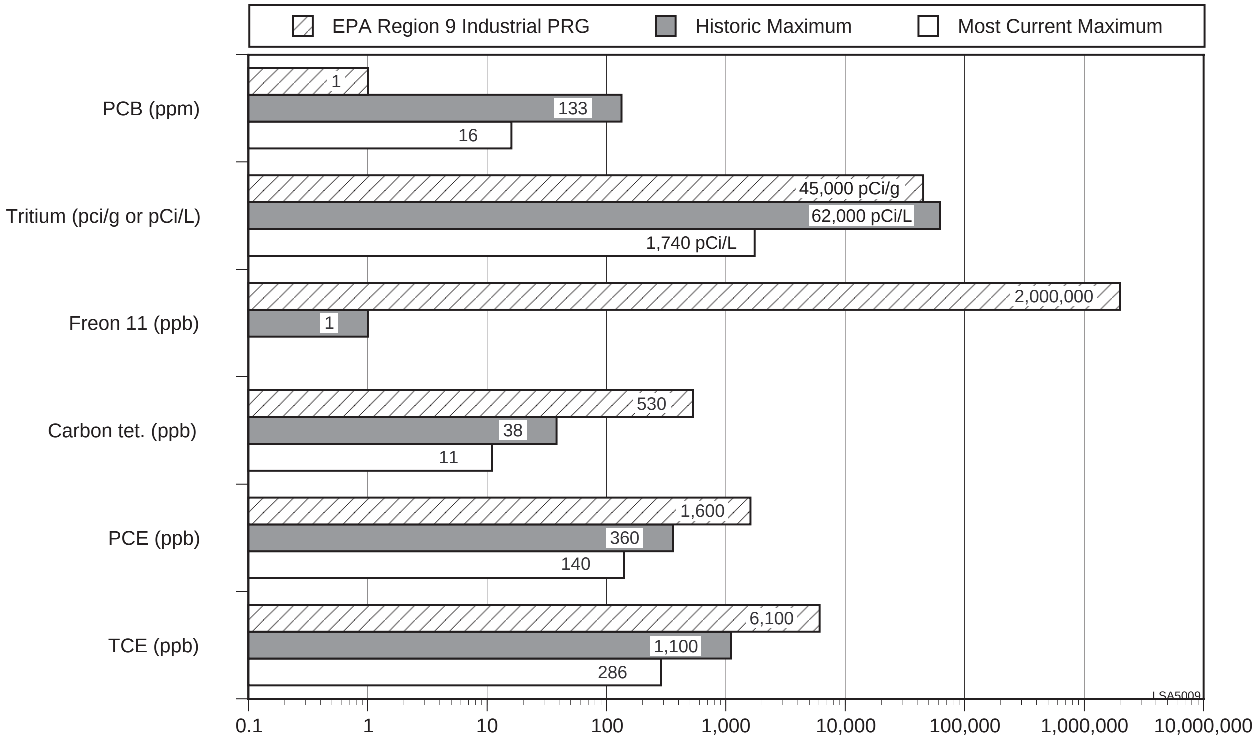

FIGURE 3.12 Soil Concentrations for the East Traffic Circle Area and EPA Region 9 Industrial Preliminary Remediation Goals (PRGs)

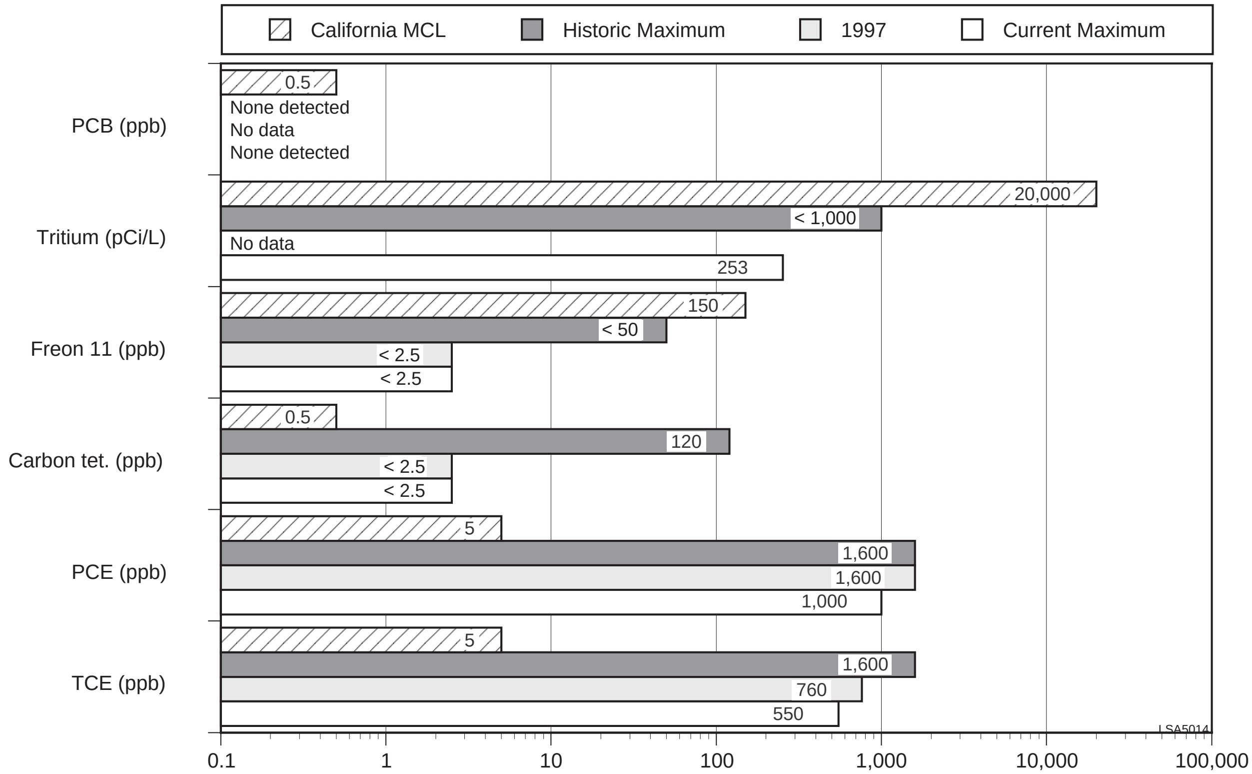

FIGURE 3.13 Groundwater Concentrations for the East Traffic Circle Area and Maximum Concentration Limits (MCLs) for Drinking Water

- The maximum TCE concentration in sediment was 1,100 ppb; PCE had a maximum concentration of 360 ppb in SIB-ETC-001 (see Table 3.1).

- In 1991, tritium was detected in the pore water of a few unsaturated sediment samples at concentrations up to 62,000 pCi/L. This measured value is about 10,000 times greater than an equivalent soil concentration value (6.2 pCi/g) because only about 10% or less of the weight of soil is moisture. Because of the half-life of tritium (12.3 years), soil concentrations values today in this sample would be below the 5-pCi/g limit for disposal. It was recently detected in groundwater in only one of two wells tested at 253 pCi/L, well below the MCL.

- One PCB (Aroclor 1254) was detected in an unsaturated sediment sample from a depth of 0 m at a concentration of 133 ppm; recent cleanup activities have reduced PCB levels to less than 18 ppm (Joma 2000).

- PCBs have not been detected in groundwater samples, including samples from new monitor well W-1403.

3.6.7 East Gate Drive Area

No hazardous materials are known to have been used, stored, handled, or disposed of in the East Gate Drive Area (Figure 1.1). However, an elevated concentration of PCE was detected in a sediment sample collected from a depth of 1.5 m (5 ft) in a borehole drilled as part of the preconstruction sampling for the Western Area Power Association powerline project. Because of this discovery, additional subsurface source investigations were performed. Those investigations included 54 SVS points, 16 boreholes, and 1 monitor well before October 1997. Results of these surveys and those of studies conducted pursuant to the Joint Stipulation and Order are presented in Tables 3.1 (soil) and 3.2 (groundwater) and illustrated graphically in Figures 3.14 and 3.15. Major observations related to contaminants in the East Gate Drive Area are:

- VOCs, at a concentrations up to 1.3 ppb have been detected in groundwater. No current individual VOC concentration is above its MCL.

- The maximum TCE concentration (1.3 ppb) was found in well W-221; this value decreased to <0.5 ppb in December 1996 (Table 3.1).

- PCE was detected in unsaturated sediments, mostly within the upper 3 m (10 ft) and generally at concentrations less than 500 ppb. The highest concentration detected was 9,800 ppb PCE in a sample collected at the 1.5-m (5-ft) level from a preconstruction borehole.

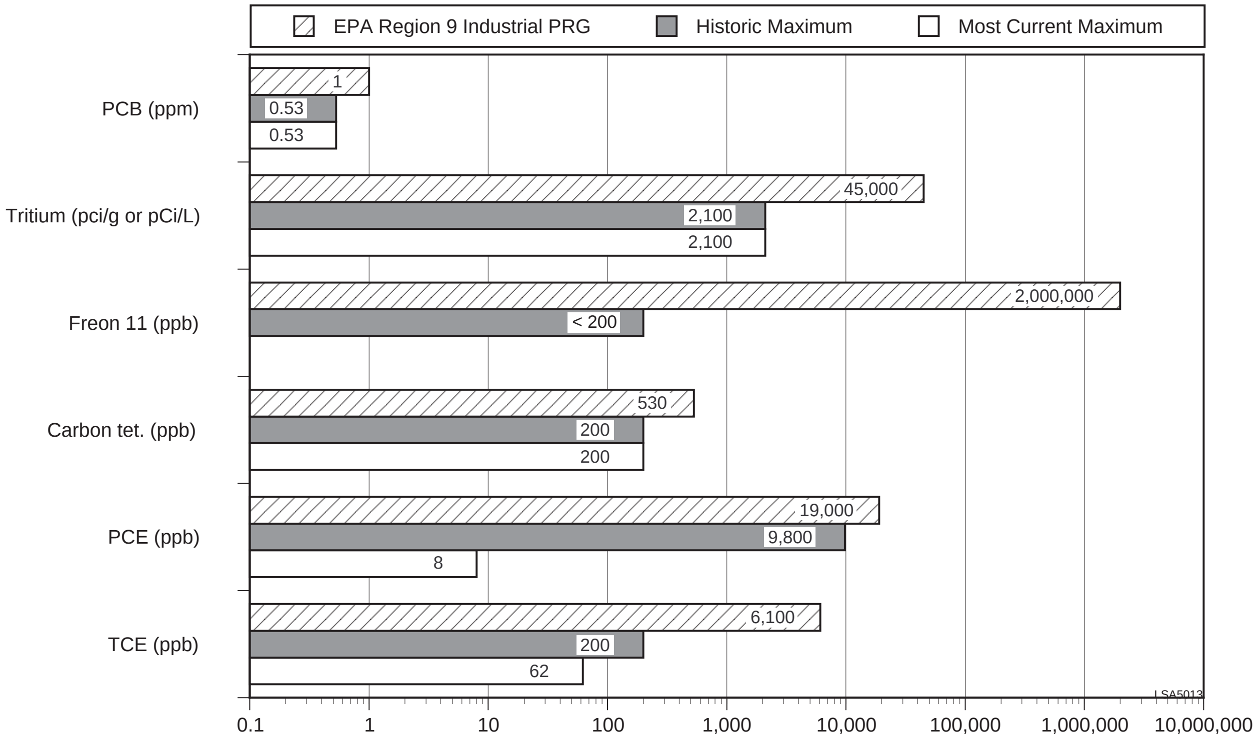

FIGURE 3.14 Soil Concentrations for the East Gate Drive Area and EPA Region 9 Industrial Preliminary Remediation Goals (PRGs)

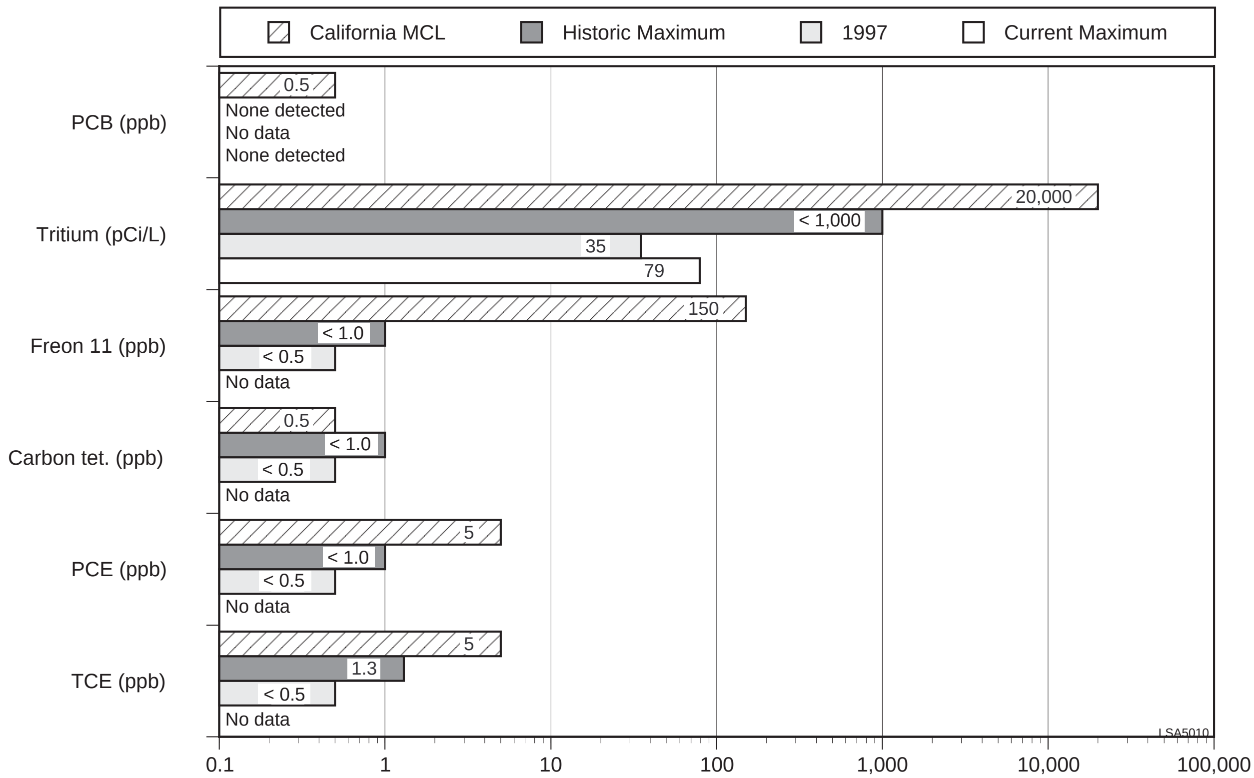

FIGURE 3.15 Groundwater Concentrations for the East Gate Drive Area and Maximum Concentration Limits (MCLs) for Drinking Water

- Tritium was detected at up to 2,100 pCi/L in the pore water in unsaturated sediment samples and was not detected above 1,000 pCi/L in groundwater. This measured value is about 10,000 times greater than an equivalent soil concentration value (0.21 pCi/g) because only about 10% or less of the weight of soil is moisture. Because of the half-life of tritium (12.3 years), soil concentrations values today in this sample would be below the 5-pCi/g limit for disposal. In 1999 no soil samples contained tritium above the 2-pCi/g detection limit, and the maximum soil moisture concentration was 1,740 pCi/L.

- PCBs were detected in unsaturated sediment samples at a concentration of 0.53 ppm in March 1999. No PCBs were detected in groundwater from downgradient wells completed in HSU 2.

3.6.8 NIF Construction Area

No historical data were found indicating that hazardous materials had been used, stored, handled, or disposed of in the NIF Construction Area. Subsurface investigations before October 1997 included samples from one HSU 2 monitor well in the area and two downgradient HSU 2 monitor wells within 76 m (250 ft) of the area. Results of these surveys and those of studies conducted pursuant to the Joint Stipulation and Order are presented in Tables 3.1 (soil) and 3.2 (groundwater) and illustrated graphically in Figures 3.16 and 3.17. Major observations related to contaminants in the NIF Construction Area are as follows:

- No groundwater from wells in the NIF area currently contains contaminants above the MCLs. The NIF site is outside the area where VOCs in groundwater were above MCLs in 1998.

- TCE and PCE concentrations of up to 200 ppb were detected in unsaturated sediment samples collected in the NIF area. Carbon tetrachloride has a historical maximum of 1.5 ppb in the area.

- Groundwater samples collected from the one HSU 2 well in the area have historically contained total VOCs at concentrations mostly less than 10 ppb. The maximum TCE concentration measured was 16 ppb. In April 1997, this value decreased to <0.5 ppb.

- Tritium levels in unsaturated sediments were reported to be less than 5,200 pCi/L, which corroborates that there has been no known or historical information about a tritium source in the NIF Construction Area.

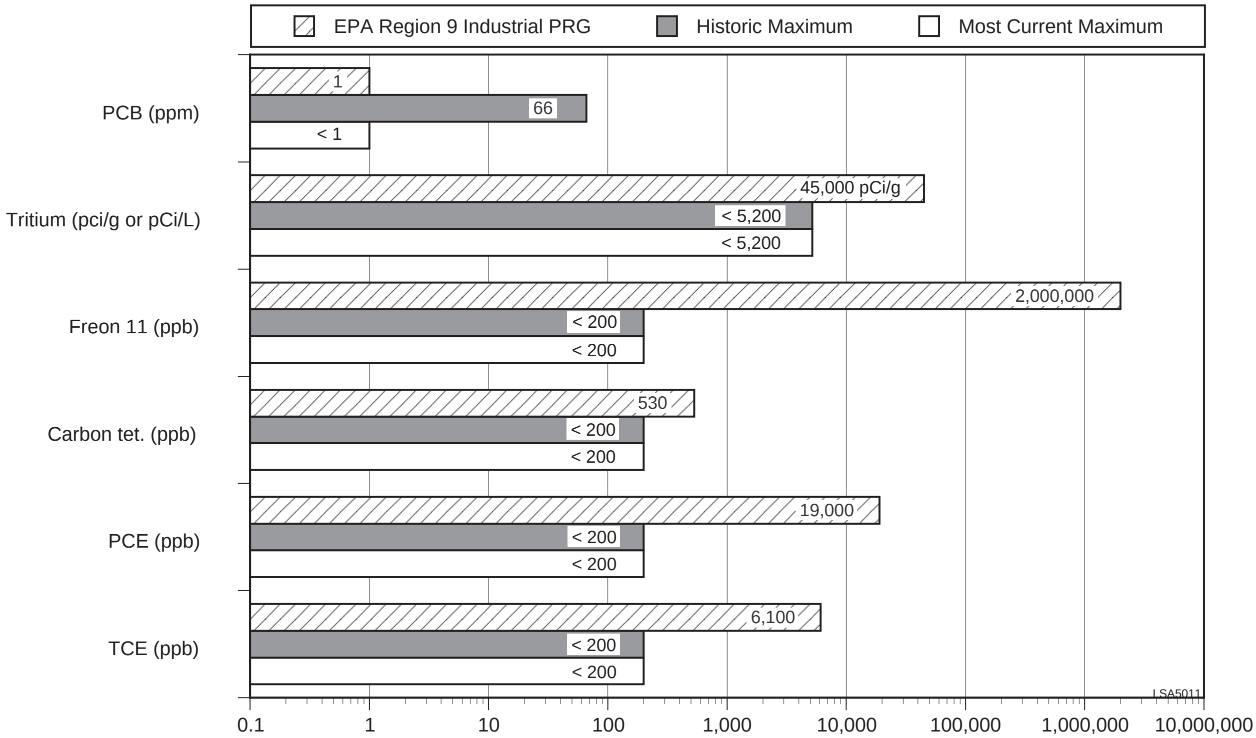

FIGURE 3.16 Soil Concentrations for the NIF Construction Area and EPA Region 9 Industrial Preliminary Remediation Goals (PRGs)

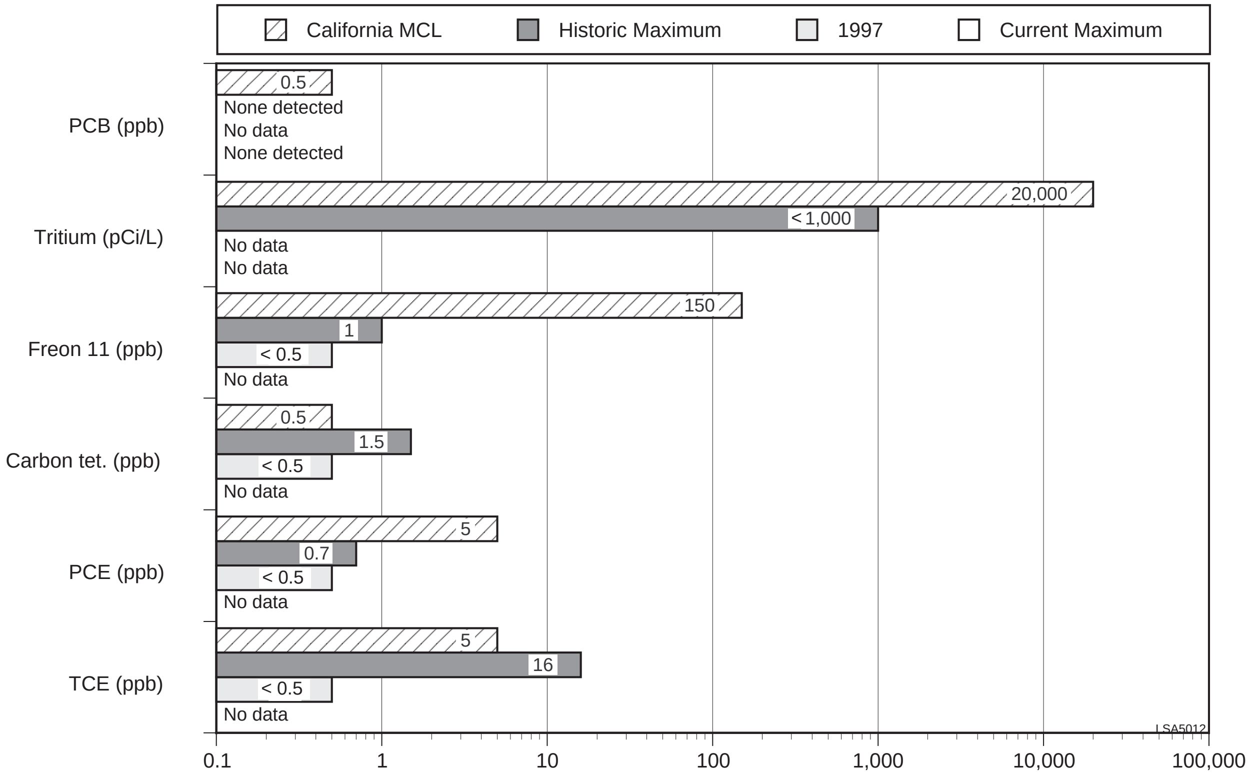

FIGURE 3.17 Groundwater Concentrations for the NIF Construction Area and Maximum Concentration Limits (MCLs) for Drinking Water

- Tritium concentration in the groundwater was less than the detection limit of 1,000 pCi/L.

- PCBs have not been detected (detection limit of 0.0005 ppm) in any of the wells in the vicinity of the excavated capacitors and contaminated soil.

- The maximum PCB concentration in soil was 66 ppm before cleanup. Concentrations are now less than 1 ppm (Bainer and Berg 1998).

3.7 ONGOING REMEDIATION ACTIVITIES AT THE SITE

A number of extraction wells and groundwater treatment facilities have been constructed to reduce contamination at LLNL (Berg et al. 1997). These facilities are shown in Figure 3.18. In 1997, there were three extraction wells and one fixed (TFD) and two portable groundwater treatment units (TFD East and TFD West) in the vicinity of the Helipad Area. Portable groundwater treatment unit TFD Southeast started operation in March 1998.

Pumping at the extraction wells has modified the groundwater elevations. Elevations for HSUs 1 through 5 are shown in Figures 3.19 through 3.24. The shallowest unit (HSU 1) is unsaturated in the vicinity of the NIF site (Figure 3.19). Groundwater flow in the vicinity of HSUs 2 and 3 (Figures 3.20 through 3.22) is to the west-southwest. HSU 2 well W-273 (Figure 3.25) is the first well downgradient from the NIF excavation. Groundwater samples collected from this well contain no volatile organic compounds or PCBs. The effects of groundwater extraction are much more obvious in HSU 4. Extraction of groundwater from this unit has produced a 4.6-m (15-ft) deep drawdown cone of depression centered on the extraction wells; flow in this unit is radially convergent on the extraction wells (Figure 3.23). One extraction well west of the NIF site provides groundwater capture for HSU 5, as seen in Figure 3.24. Flow in the vicinity of the NIF in this groundwater unit is to the west-northwest. As indicated in Table 3.2, there has been a substantial decrease in groundwater contamination for some substances compared with historic maximums because of the active remediation activities being conducted at the site.

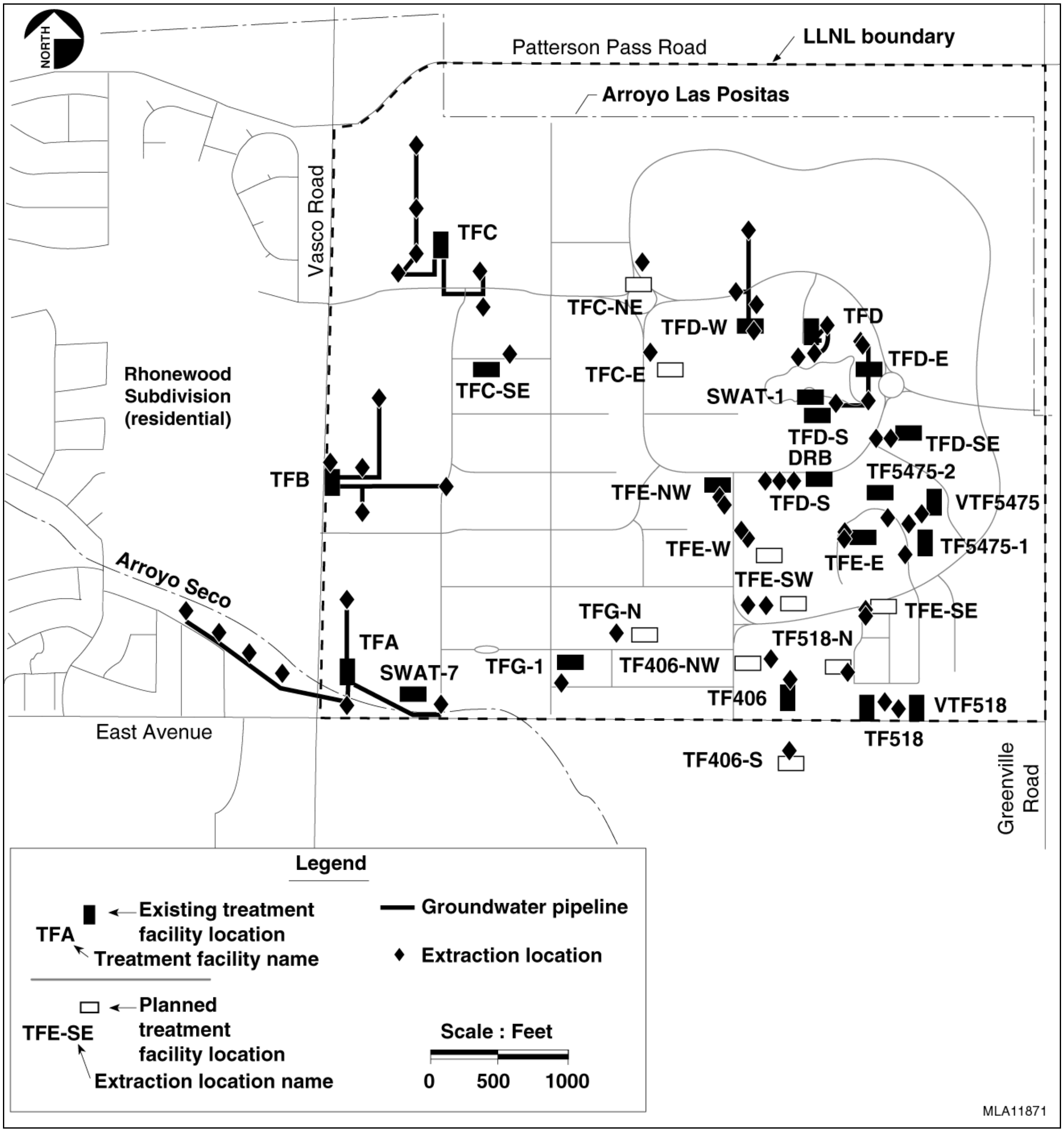

FIGURE 3.18 Planned and Existing Groundwater and Soil Vapor Extraction Locations at the LLNL Site

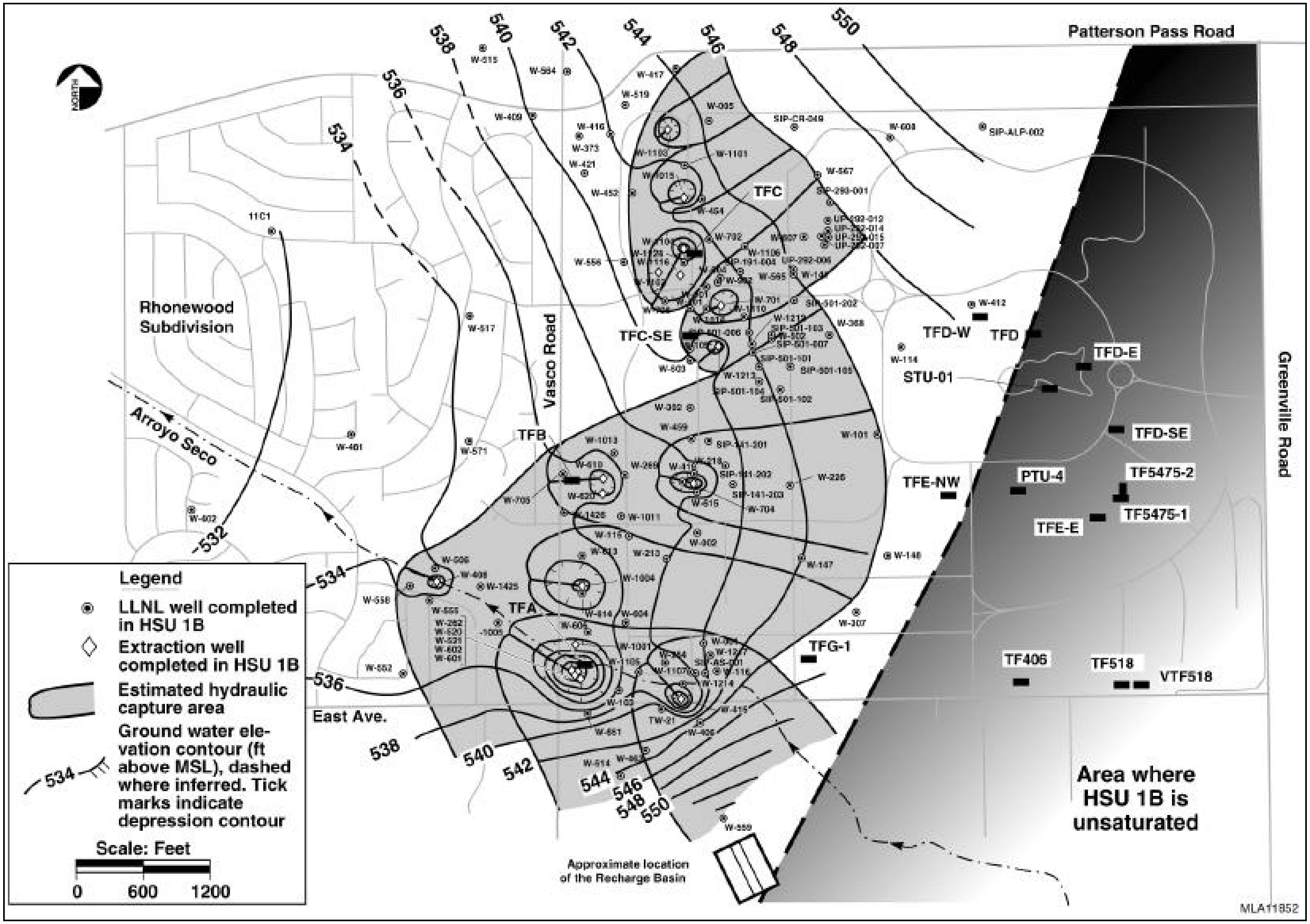

FIGURE 3.19 Groundwater Elevation Contour Map Based on Water Levels Collected from 130 Wells Completed within HSU 1B Showing Estimated Hydraulic Capture Areas, LLNL and Vicinity, February 1999

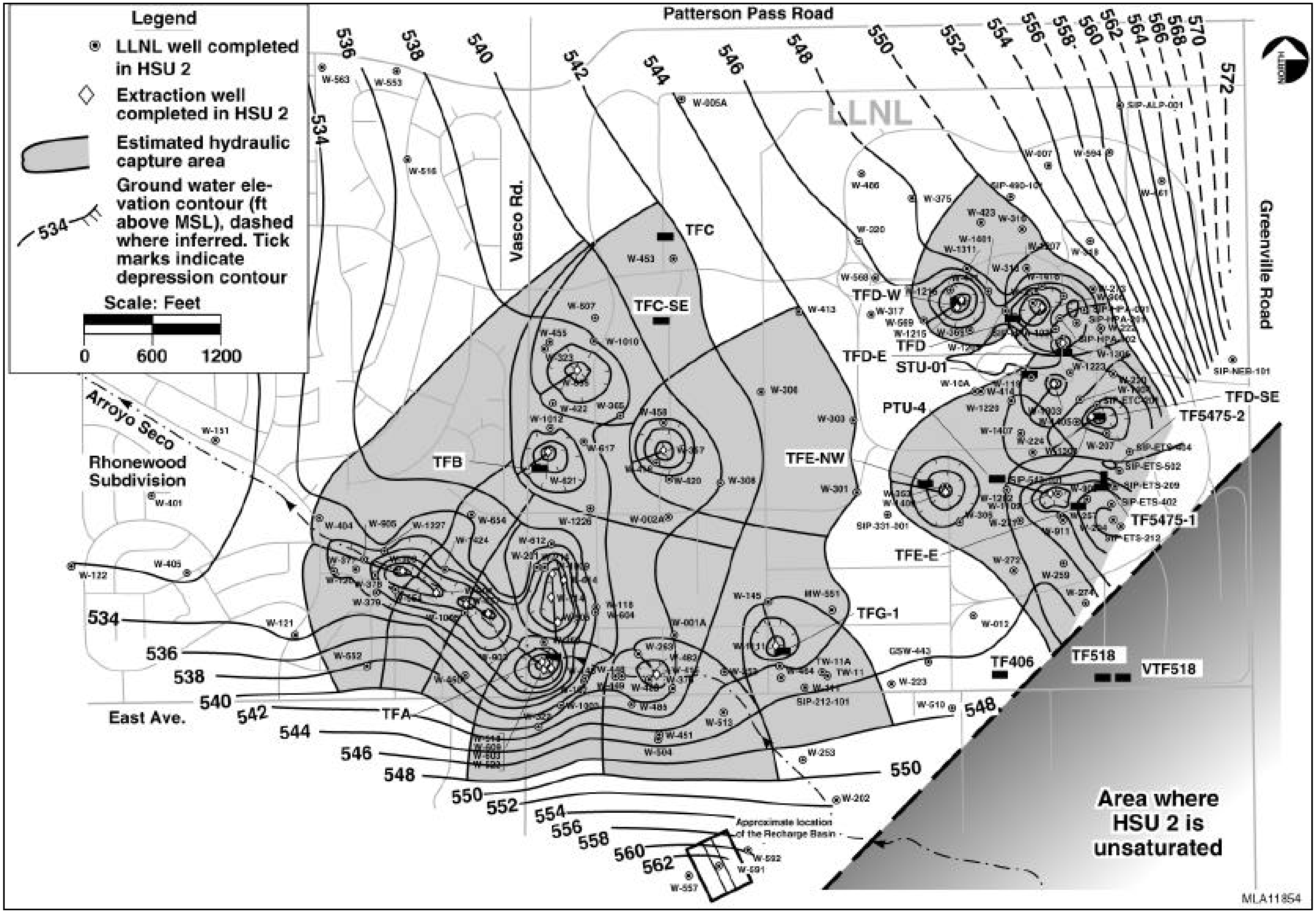

FIGURE 3.20 Groundwater Elevation Contour Map Based on Water Levels Collected from 167 Wells Completed within HSU 2 Showing Estimated Hydraulic Capture Areas, LLNL and Vicinity, February 1999

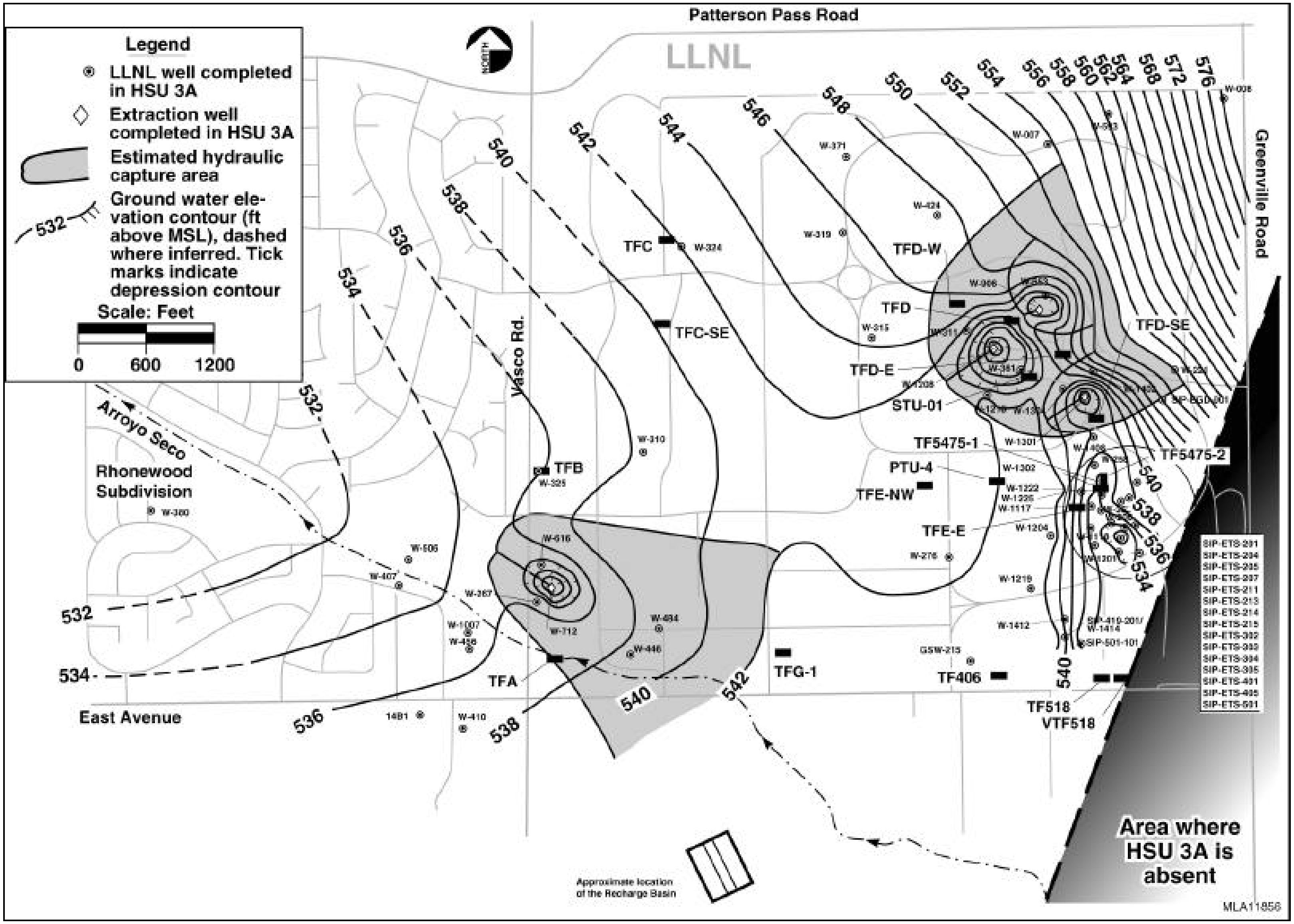

FIGURE 3.21 Groundwater Elevation Contour Map Based on Water Levels Collected from 63 Wells Completed within HSU 3A Showing Estimated Hydraulic Capture Areas, LLNL and Vicinity, February 1999

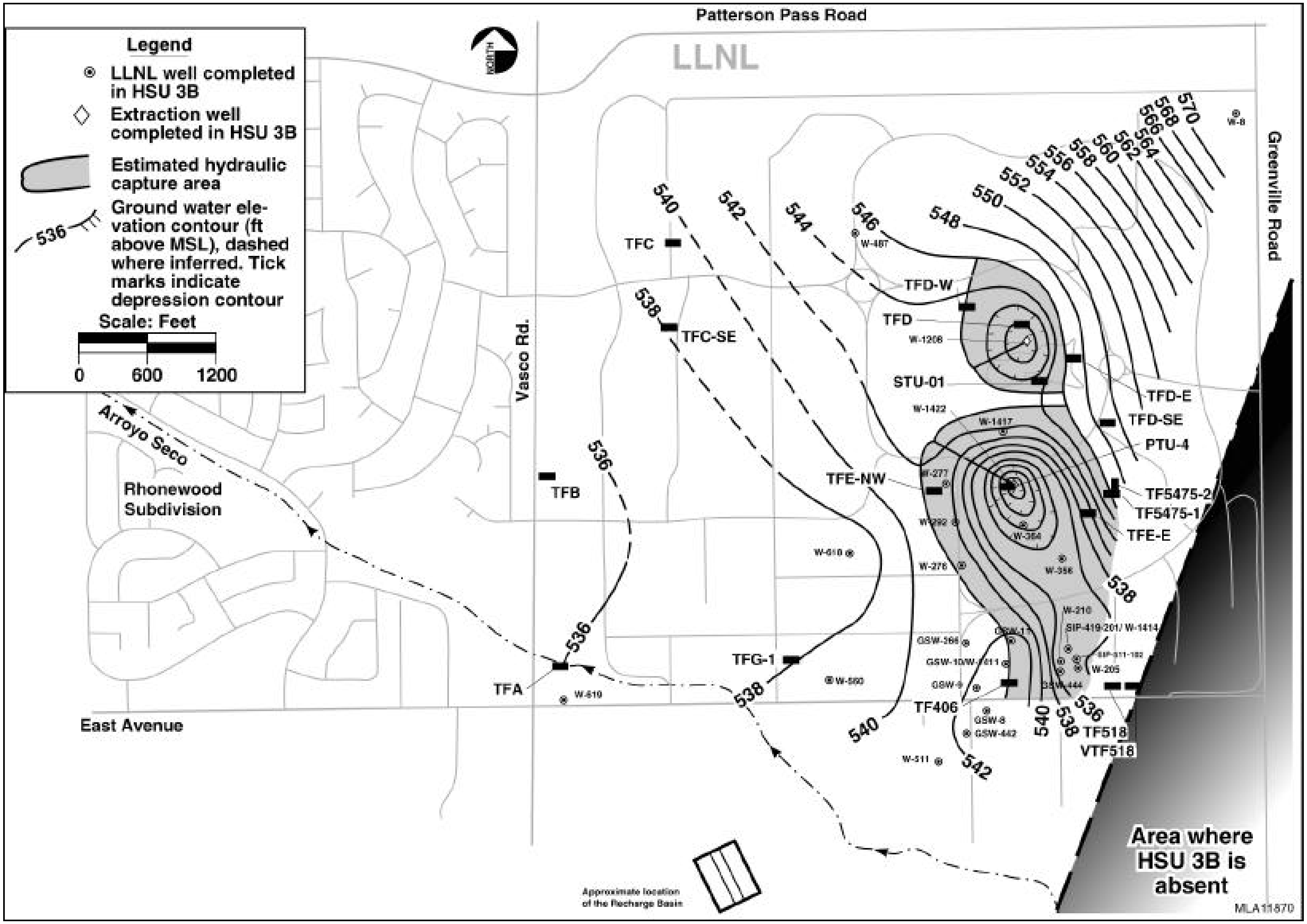

FIGURE 3.22 Groundwater Elevation Contour Map Based on Water Levels Collected from 25 Wells Completed within HSU 3B Showing Estimated Hydraulic Capture Areas, LLNL and Vicinity, February 1999

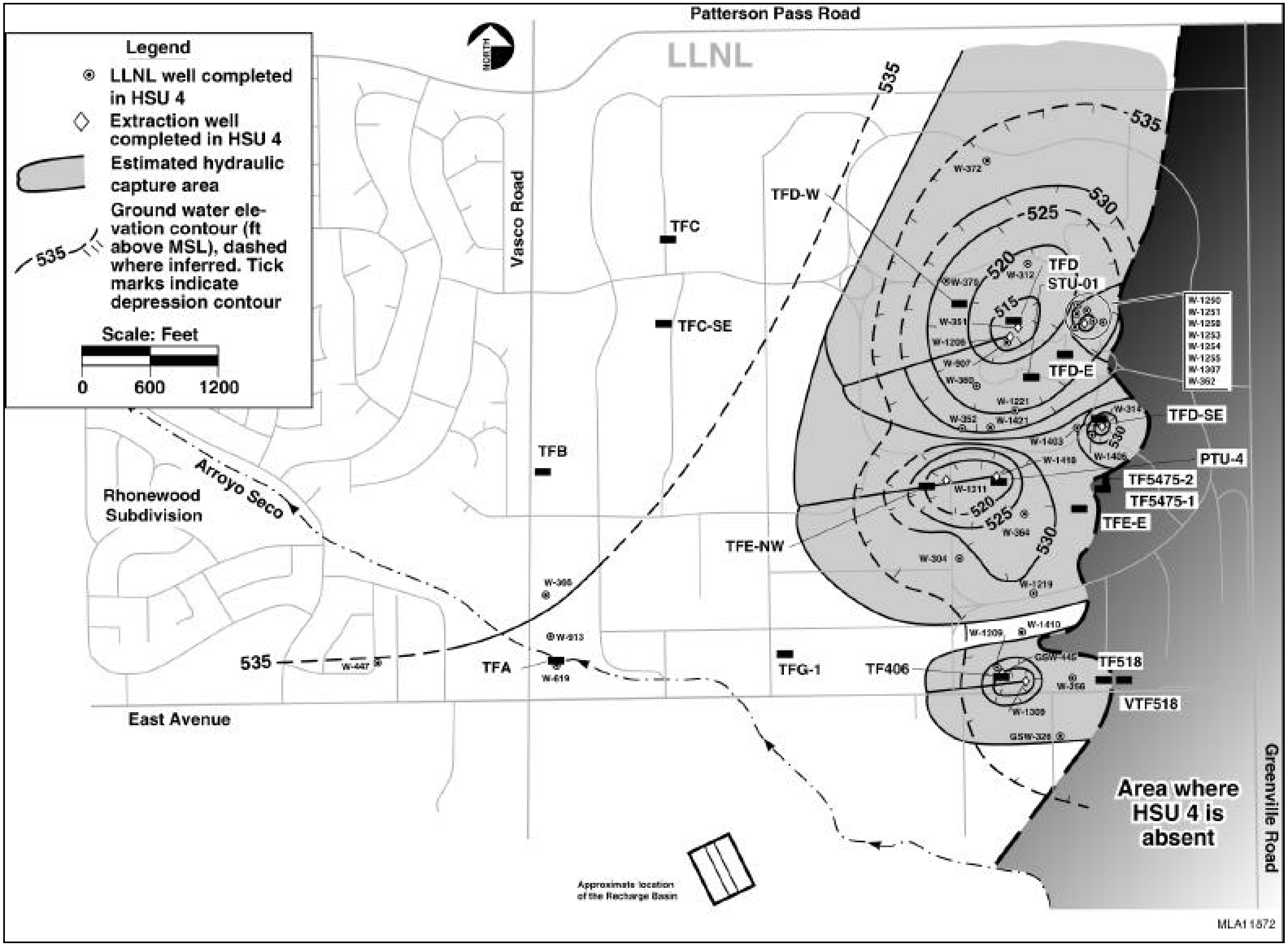

FIGURE 3.23 Groundwater Elevation Contour Map Based on Water Levels Collected from 35 Wells Completed within HSU 4 Showing Estimated Hydraulic Capture Areas, LLNL and Vicinity, February 1999

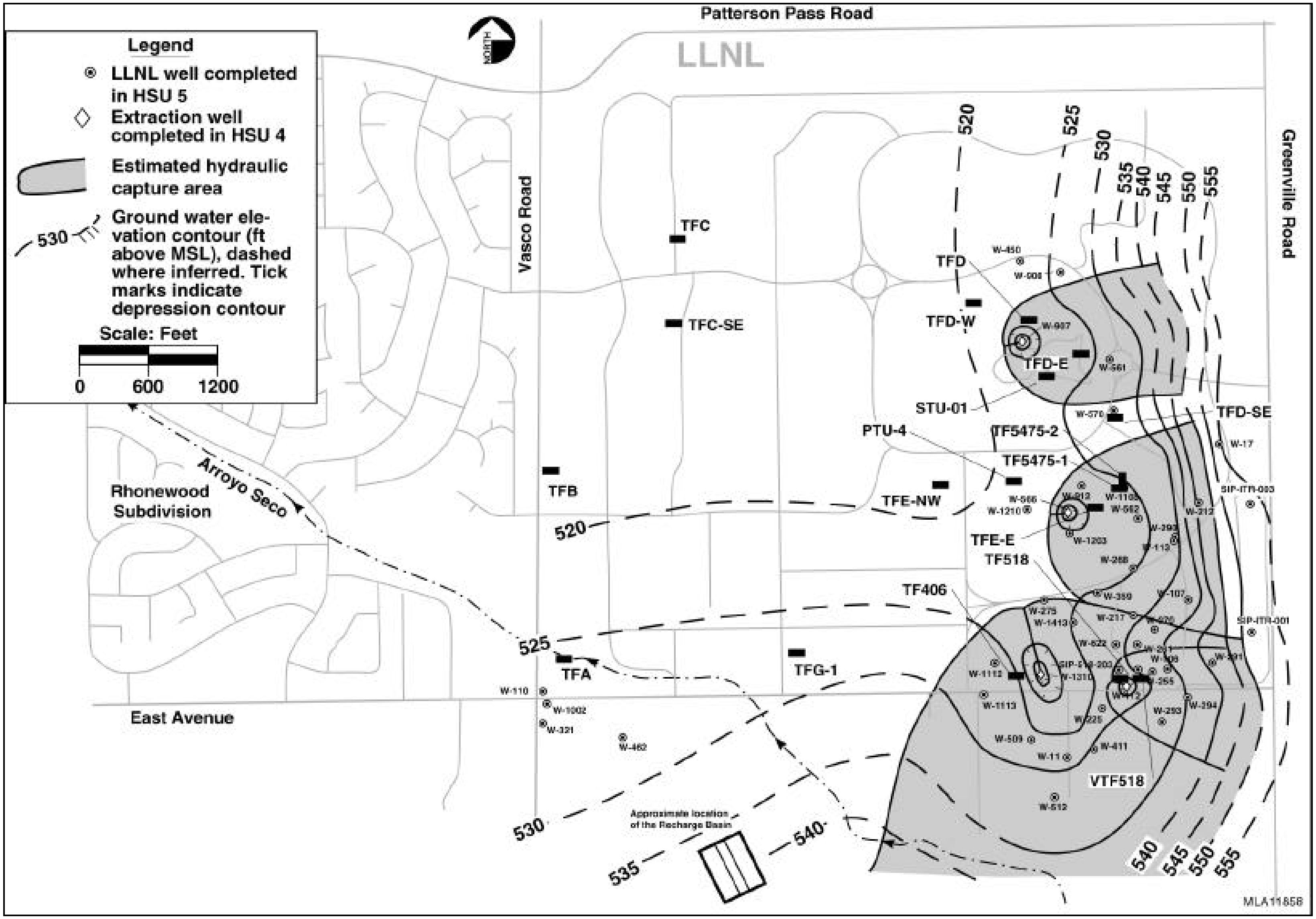

FIGURE 3.24 Groundwater Elevation Contour Map Based on Water Levels Collected from 46 Wells Completed within HSU 5 Showing Estimated Hydraulic Capture Areas, LLNL and Vicinity, February 1999

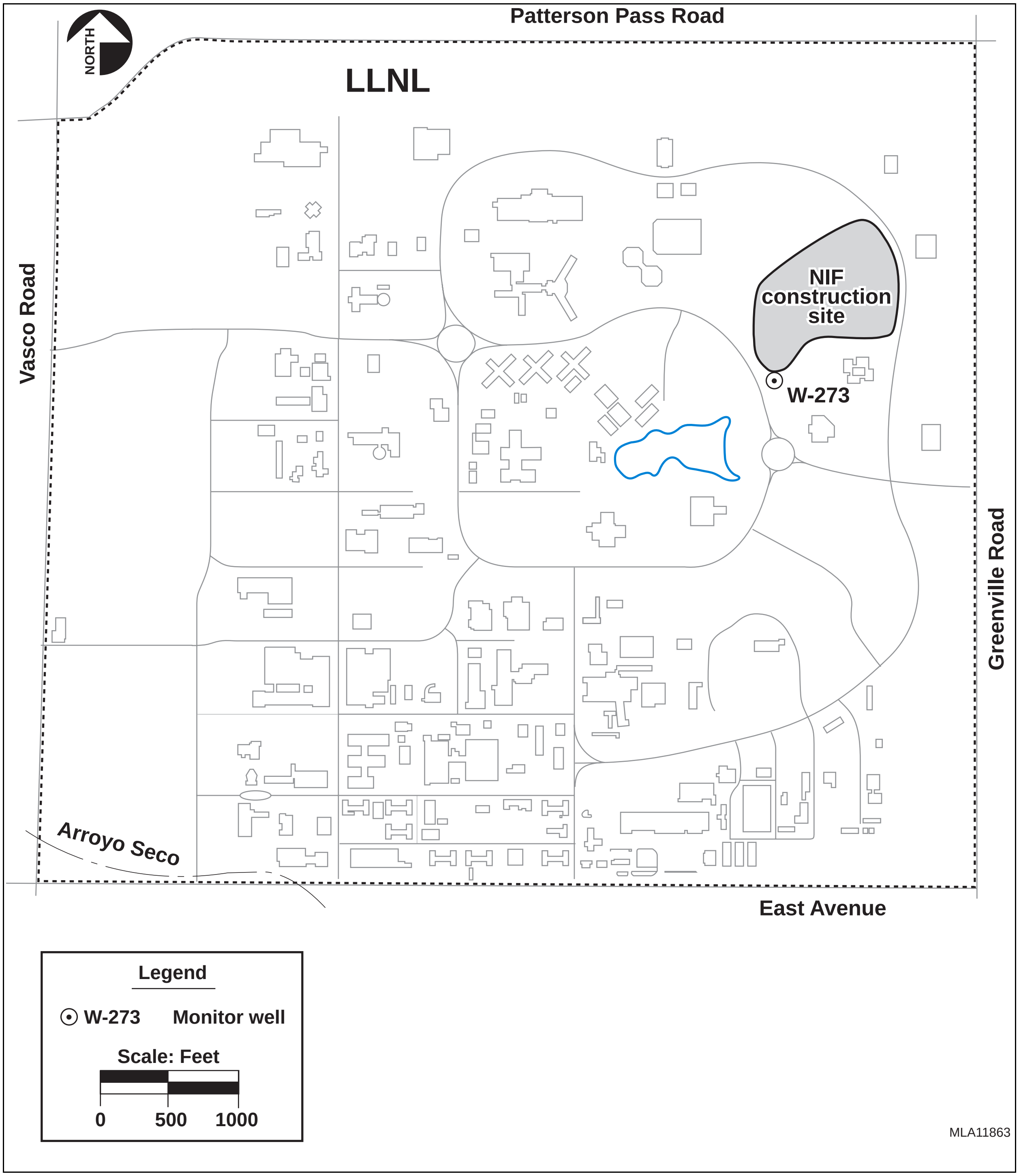

FIGURE 3.25 Location of Monitor Well W-273 Downgradient of the NIF Construction Site

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